Water Plant Optimization Study

OTTAWA-BRITTANIA WATER TREATMENT PLANT

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WATER PLANT OPTIMIZATION STUDY

Ottawa-Brittania

Water Treatment Plant

Project No. 7-2034

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Please note that some of the recommendations contained in this report may have already been completed at time of publication. For more information, please contact the local municipality, or the Water Resources Branch of the Ministry of the Environment.

Flocculators

It has been noted that G values in the winter are lower than those prescribed for flocculation basins. Although retention times appear adequate, this does indicate a lack of flexibility for varying plant flows. Nonetheless, the flocculator performance is good. It is recommended that during periods of low flow during the winter months, an evaluation of the removal from service of one set of flocculators be undertaken. This will effectively increase the flow to the remaining flocculators and may result in improved flocculator performance. Alternatively, the installation of hydraulic control devices may provide a more controlled method for increasing G and Gt values.

Settling

It was found that surface and weir loading rates were high, nonetheless, settled water turbidities are generally good. The worst case is in winter flow conditions where turbidities reach 1-2 FTU. The settling basins in the plant expansion will contain plate settlers. Since there is some indication of short-circuiting, it is recommended that a single basin in the existing plant be isolated and fitted with plate settlers for trial purposes.

Filters

Filter operation is excellent in providing filtered water turbidities generally less than 0.2 FTU for a variety of settled water qualities. Core samples taken after a backwash revealed generally clean media.

Disinfection

It was found that pre-chlorination dosages and detention times have provided adequate pre-disinfection. Settled water has consistently shown positive free chlorine residuals. Generally, tri-halomethane (THM) levels in treated water were less than 350 µg/L. In order to minimize THM formation, it is recommended that alternatives be investigated such as the use of alternative oxidants (eg. ozone), activated carbon or the movement of chlorine addition to the beginning of the settling basins.

Two concerns with post-disinfection are the limited contact time and the high pH of the water at the point of chlorine addition.

Fluoride

It was found that the hydrofluosilicic acid (HFS) storage area contained no flood wall.

It is recommended that a flood wall be installed to prevent the escape of HFS should a tank leak occur.

pH Control

The existing pH control system produces lime fines. This has been partially controlled by movement of the lime addition point to the head of the clearwell, thereby allowing the fines to settle out in the clearwell as opposed to the distribution system. However, this does not allow for an optimum disinfection environment due to the high pH in the clearwell. The use of a degritter or lime saturator will allow moving the lime addition point back to the clearwell discharge. Alternatively, sodium hydroxide (NaOH) addition does not have the problems of grit associated with lime.

It should also be noted that although the finished water pH is high, it is still midly aggressive.

Therefore, it is recommended that the point of lime addition be moved to the clearwell exit (see lime recommendation) and that the clearwell be baffled to minimize short-circuiting. It is also recommended that chloramination be evaluated as an alternative post-disinfectant.

Coagulant

Based on jar tests, it is recommended that alum continue to be used as a coagulant. Optimization of alum dosing may be required to lower residual aluminum levels in the treated water which has occasionally been higher than 0.1 mg/L. It is understood that the use of a streaming current type monitor for dosage control has been tested at plant scale. However, since alum dosage is based on pH reduction requirements, streaming current was not considered useful.

Coagulant Aid

The point of addition of the coagulant aid may not be optimum for coagulation/flocculation. It is noted that the expansion does address this problem by allowing flexibility in the selection of the addition point relative to alum addition.

TABLE OF CONTENTS

CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

INTRODUCTION AND TERMS OF REFERENCE

The Drinking Water Surveillance Program (DWSP) of the Ontario Ministry of the Environment is intended to provide an up-to-date database on drinking water quality in Ontario. In conjunction with DWSP, a specific plant investigation and process evaluation study is desired for each plant entering the program. Consequently, Water Plant Optimization Studies (WPOS) are undertaken to determine the existing operating conditions, water quality, and potential for optimization of existing unit process. Specifically, emphasis has been placed on the particulate removal and disinfection efficiency of the water treatment plant. The terms of reference for this study are included in Appendix E.

The Regional Municipality of Ottawa-Carleton operates two water treatment facilities serving a population of approximately 548 000 in 1987. This document is the Water Optimization Study for the Britannia Water Treatment Plant (WTP) located on a 60 ha site at the foot of the Deschere Rapids in the Regional Municipality of Ottawa-Carleton. Figure A1 illustrates the geographical location of each of the two plants.

The Britannia WTP has been treating Ottawa River Water since 1961. The raw water is typically high in colour, low in turbidity and with little hardness. Plant performance in terms of both turbidity removal and disinfection has been excellent. Treated water turbidity levels were generally less than 0.2 FTU, and fecal coliforms were detected in only one sample in the period 1983 to 1986.

This report has been organized into the following sections:

Section A - Raw Water Source

This section describes the chemical, physical and bacteriological quality of the water treated at the plant.

Section B - Flow Measurement

This section presents a summary of all flow monitoring equipment at the plant.

Section C - Process Equipment

This section presents descriptions of each of the unit treatment processes, chemical systems and sampling systems existing at the plant.

Section D - Plant Operation

In this section, the methodologies used for operation of the plant in general and with respect to each process component, are presented.

Section E - Plant Performance (Particulate Removal)

This section contains a review of plant particulate removal processes including coagulation, flocculation, sedimentation and filtration, based on historical performance data. Recommendations are made for improvements to the present system.

Section F - Plant Performance (Disinfection)

This section contains a review of plant disinfection practices, based on historical disinfection performance. In addition, there is a discussion of the formation of chlorinated by-products. Concerns to the present system are addressed and recommendations are presented.

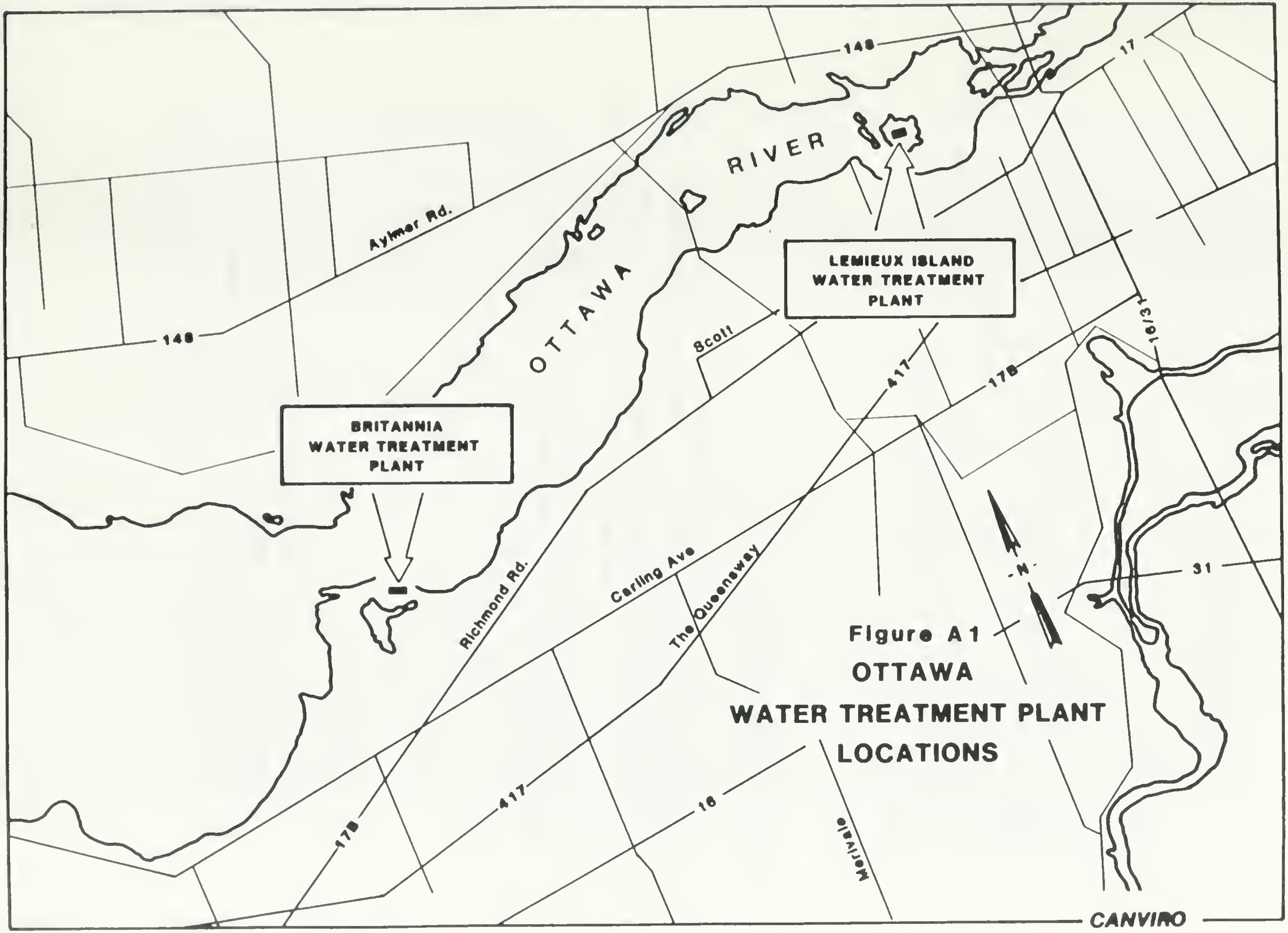


Figure A1
OTTAWA
WATER TREATMENT PLANT
LOCATIONS

A. RAW WATER SOURCE

A.1 Source

The Ottawa River is used as the source of drinking water supply for the Britannia Water Treatment Plant. The plant intake is located approximately 300 m from the bank of the Ottawa River just adjacent to Pinecrest Creek. It consists of a section 274 m long and 1650 mm in diameter and a second section 151 m long and 1950 mm in diameter. Twelve fibreglass reinforced plastic (ERP) intake bells are connected to the end of the intake pipe.

A.2 General Quality

The river water is typically high in colour, low in turbidity and relatively soft. Colour is typically 40 - 50 TCU and turbidity is characteristically 2.0 - 2.8 FTU. Total hardness is approximately 31 - 42 mg/L as $CaCO_3$. The overall range of variation for the years 1983 to 1986 for general raw water quality parameters is as follows:

Parameter	Range
Turbidity (FTU)	0.6 - 25
Colour (TCU)	25 - 75
Temperature (°C)	0.1 - 25.0
pH	6.8 - 7.6
Alkalinity (mg/L as $CaCO_3$)	12 - 35
Hardness (mg/L as $CaCO_3$)	14 - 80
Aluminum (mg/L as Al)	0.01 - 0.65
Iron (mg/L as Fe)	0.13 - 0.24

The high colour levels are a result of decayed vegetation and swamp run-off in the heavily forested Ottawa River watershed whose catchment area above the water treatment plant intake is approximately 89 600 km². Turbidity levels in the raw water vary on an annual cycle with the highest levels (4-9 FTU) occurring in the spring coincident with snow-melt and precipitation. The lowest levels occur in late summer and early fall when turbidity drops to 1-2 FTU and remains there during the winter. Colour levels are more or less constant over the year with a slight decrease in monthly averages being observed in late summer and early fall.

Table 2.0 (Appendix A) presents raw water turbidity, colour, temperature and pH data for the years 1983 - 1986. These data were obtained from daily in-plant analyses. Alkalinity, hardness and aluminum data were also obtained from in-plant analyses. Alkalinity measurements were made daily while hardness was measured weekly. Section D.6 presents details of sample and analysis frequencies, sampling procedures and test methods for selected parameters.

Additional raw water quality data for physical-chemical parameters, heavy metals, trace organics and bacteria are presented in Table 4.0 for the period September 1986 to June 1987 (partial data only for June 1987). These results were derived from sampling and analysis performed under the Drinking Water Surveillance Program.

River water bacteriological quality is variable with total coliform densities ranging from 2 CFU[1]/100 ml to 630 CFU/100 ml for the period 1983 to 1986. Fecal coliform densities typically ranged from 18 to 35 CFU/100 ml. Bacteriological analyses were performed by the Ontario Ministry of Health Laboratories, Ottawa, daily.

Discussions with MOE staff in Ottawa have indicated no industrial dischargers are located in proximity of the Britannia Water Treatment Plant.

Algae counts ranged from 5 to 253 ASU[2] during the period 1983 to 1986. As may be expected algae increased during the months of May, June, July. Algae enumerations are performed by the in-plant laboratory once per month. Details of raw water algae and bacteriological analyses are presented in Tables 5.0 and 6.0 to 6.3 in Appendix A, respectively.

[1] CFU - colony forming units
[2] ASU - aerial standard units

B. FLOW MEASUREMENT

Table B.1 contains a summary of all flow measurement and monitoring at the Britannia Water Treatment Plant.

Once per year a calibration of each flow measurement device is carried out by the Electrical Instrument Section. This involves the use of a Druck DP calibrator or a standard water column which is then connected to each Bristol Differential Pressure Transmitter. The recorder value is then checked for accuracy and adjustment of the transmitter is made if necessary. A calibration of any DP cell will also be made, as required, if a discrepancy occurs.

The Druck DP calibrator is calibrated against a standard mercury manometer.

The raw, treated and filtered installations generally conform with accepted metering practice. The approach pipe sections upstream of the treated and filtered water venturis are minimal in length (only 4 diameters of straight unobstructed pipe). A small but undefinable degree of inaccuracy likely results from this deviation from ideal practice.

Table B.1
FLOW MEASUREMENT
BRITANNIA WATER TREATMENT PLANT

Service	Number	Type/Size	Capacity Range (each)	Transmitter	Location	Instrumentation
Raw Water	2	VENTURI 1220 x 760 mm	225 ML/d @ 1454 mm water column each	Bristol Differential pressure DP 4-20 mA	Low Lift Discharge	- 7 day chart recorder with integrator - summator for the two signals
Filter Effluent	12	VENTURI 410 x 244 mm	22.7 ML/d @ 1510 mm water column each	Bristol DP 4-20 mA	Filter Effluent Pipe	- Digital indicator on filter console
Treated Water	2	VENTURI 1220 x 760 mm	225 ML/d @ 1454 mm water column each	Bristol DP 4-20 mA	Suction side of high lift pumps	- 7 day chart recorder with integrator - summator for the two singals
Backwash Water	1	VENTURI 762 x 572 mm	145 ML @ 151 mm water column each	Bristol DP 4-20 mA	Discharge side of of back-wash pumps	- digital indicator on the filter console
Plant Service	1	VENTURI	8.2 ML/d @ 1661 mm water column each	Bristol DP 4-20 mA	Basement of pump station	- 7 day chart recorder

C. PROCESS COMPONENTS

C.1 General

The Region's water distribution service is divided into zones, each with varying flow and pressure requirements. Water is conveyed from the two purification plants into the system via a network of trunk feedermains and pumps stations which interconnect the zones. The Britannia Water Treatment plant is located by the Ottawa River on a 60 ha site at the foot of the Deschene Rapids. The plant was completed in 1961 and currently supplies Pressure Zones 1W, 2W and 3W in the Regional Municipality of Ottawa-Carleton (RMOC) distribution system.

The plant is a conventional plant for treating surface waters. Unit processes consist of pre-chlorination, coagulation, flocculation, sedimentation, dual media filtration, final pH adjustment for distribution system corrosion control, fluoridation and post-chlorination. The coagulation process uses liquid alum as the primary coagulant and activated silica as a coagulant aid.

The plant is currently undergoing an extensive automation program that will result in comprehensive computer control over plant operation. Figure C1 is a process flow-sheet for the existing plant. Figure C2 is a hydraulic profile for the plant. Figures C3, C4 and C5 present the Britannia site plan, piping and process diagram and detailed block schematic respectively.

C.2 Design Data

a) Plant Capacity

The Britannia Water Treatment Plant can produce a maximum of 225 ML/d. Beyond this capacity the settled water ducts feeding the filters begin to overflow. As well, this rate can only be sustained for an estimated 6-8 hours as sufficient water for backwashing purposes is not available. The plant will operate at 192 ML/d for sustained periods (hydraulic limitation).

The process range is between 220-250 ML/d in the winter and 275-315 ML/d in the summer. The plant nominal rated capacity as per the RMOC "Water Purification Plants Master Plan, May 1985" is 225 ML/d.

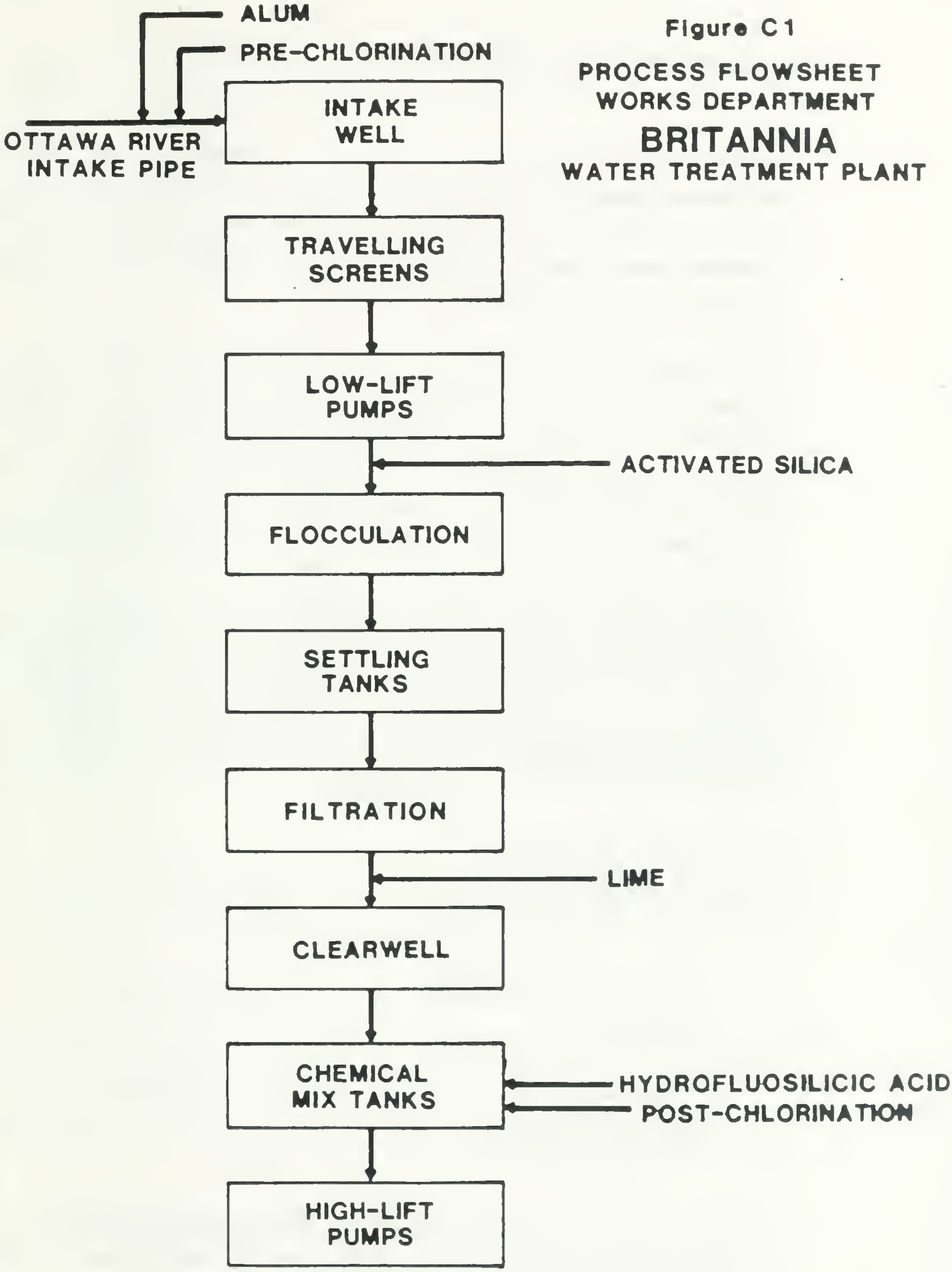


Figure C1

PROCESS FLOWSHEET
WORKS DEPARTMENT
BRITANNIA
WATER TREATMENT PLANT

CANVIRO

C.3 Process Component Inventory

a) Intake

Raw water from the Ottawa River is conveyed to the plant via 425 m of concrete pipe. Twelve fibreglass reinforced plastic (FRP) intake bells are connected to the end of the intake pipe. Each bellmouth has a diameter of 2.0 m giving an overall intake area of 37.7 m^2.

The intake pipe consists of two sections. The original intake constructed in 1960 is 274 m long with a diameter of 1650 mm and is built of AWWA C-300 concrete pipe. Flows from the adjacent Pinecrest Creek adversely impacted water quality at the intake and accordingly the intake was extended in 1977. The extension is 151 m long, 1950 mm in diameter and is constructed of AWWA C-302 concrete pipe. An intake surge tank of 57 m^3 capacity (5.2 m x 10.2 m x 1.07 m) that is connected to the intake well is presently not in use. Raw water discharges into the two 80.3 m^3 intake wells (each 9.6 m x 2.9 m x 2.9 m). Intake nominal design capacity is 360 ML/d. Intake velocities at the various design capacities is as follows:

Plant sustained production capacity - 192 ML/d	-	0.060 m/s
Plant rated capacity - 225 ML/d	-	0.071 m/s
Intake Nominal design capacity - 360 ML/d	-	0.11 m/s

Velocities up to the current rated capacity compare favourably with the MOE maximum design guideline of 0.075 m/s (Ref. C-1).

RMOC personnel have stated that backflushing of the intake conduit has not been required.

b) Screening

Raw water enters the intake wells after passing through one of two identical screen units supplied by Chain Belt Canada Ltd. Each screen is 2.8 m wide and has a normal operating depth of 3.6 m with a maximum depth of 7 m depending on river level. Each screen is made of brass at 1.2 mesh and has a nominal design capacity of 227 ML/d. The velocity through a clean screen at nominal design capacity is 0.89 m/s while velocity at plant sustained production capacity (192 ML/d) is 0.75 m/s. Both the above velocity values fall within the MOE guideline (Ref. C-1) of 0.9 m/s with one screen in service.

Each screen is equipped with seven spray heads having a total discharge capacity of 1.25 ML/d at a line pressure of 482 kPa. There are 62 screen baskets which are part of the rotating screen assembly collecting debris on each of the travelling screens. Screened water passes through the screens to two low-lift chambers.

Frazil ice has not been a problem in the past, although icing on the screens has occurred occasionally. Plate 1 presents a view of the travelling screens.

c) Low Lift Pumping

Screened water is drawn from the low lift chambers by five low lift pumps which discharge into a pair of 1200 mm diameter discharge pipes. The first four pumps were installed in 1961 and have the following specifications:

Capacity:	63.6 ML/d
T.D.H.:	11.6 m
R.P.M.:	585 (constant speed drive)
Motor:	Tamper (electric)
Size:	111.9 kW

The fifth pump was installed in 1980 and has the following specifications:

Capacity:	95.0 ML/d
T.D.H.:	12.0 m
R.P.M.:	585 (constant speed drive)
Motor:	Brown Boveri (electric)
Size:	186.5 kW

Standby pumping power is provided by one diesel generator which has the following specifications:

Diesel Generator No. 1

Generator:	General Electric
KVA:	1000
rpm:	900
Volts:	2300
kW:	800
Driver:	Paxman

Essential power is provided by another generator during power failure (lights, instrumentation, etc.).

Diesel Generator No. 2

Generator:	Onan
KVA:	125
rpm:	1800
Volts:	600
kW:	100
Driver:	Cummins

Plate 21 shows one of the generators.

In practice no more than four pumps are operated in combination at any given time. The fifth pump is always held in stand-by.

The combination of low lift pumps used at a given time is determined by the shift supervisor based on the high lift pump combination used to provide the plant flow required by the system operator. The required flow is based on historical demand (time of day, time of year), and level in the storage system. Low lift pumps are throttled by butterfly valves in the twin discharge lines utilizing a feedback signal from the water level in the settled water duct. Details of flow control are presented in Operations section D.2.

d) Rapid Mixing

At present, the Britannia WTP does not have mechanical rapid mixing. However, a rapid mixing process is part of the Britannia WTP expansion. Alum is presently added directly into the intake pipe in the intake pipe well approximately 6 m before the low lift pumps. The low lift pumps are employed for rapid mixing. Chlorine solution is added through a separate diffuser at approximately the same point.

The total line and tank volume prior to the flocculators is as follows:

	Volume
Intake Surge well (off-line)	
Intake well	116 m^3
Low lift chambers (2 x 80.3 m^3)	161 m^3
Low lift discharge lines (twin 1200mm @ 267 m and 255 m in length respectively)	586 m^3
Total Volume	863 m^3

Accordingly, for various design flowrates the following nominal retention times can be calculated:

Plant sustained production capacity (192 mL/d)	6.47 min
Rated capacity (225 mL/d)	5.25 min

These retention times considerably exceed conventional rapid mix times. However, the effectiveness of mixing with low lift pumps as occurs here, has been questioned and the practice is generally discouraged (Ref. C-1).

e) Flocculation

The flocculation process consists of 3 sets of 3 parallel rows of 3 spiral flow flocculaters in series for a total of 27 flocculators, each with a capacity of approximately 190 m^3. The total volume of the flocculation basins is 5175 m^3, giving a total retention time of 39 minutes at the sustained production capacity of 192 ML/d. At 225 ML/d the total retention time is 33 minutes.

The flocculators are operated in the up-flow mode with the spiral flow being induced by tangentially placed inlets in each tank. Tapered flocculation is achieved by increasing the cross-sectional area of the inlet to each stage.

Appendix D contains a detailed description and evaluation of the Britannia spiral flow flocculators. Plate 9 shows a flocculator that has been emptied for cleaning. Plate 10 presents one set of flocculators and Plate 12 shows the outlet from one flocculator.

f) Settling

Each series of three flocculators (9 tanks) discharge into a rectangular settling basin through a total of six baffled

ports (two ports per tank). The dimensions of each port are 1143 mm long x 381 mm high. At 192 ML/d the velocity through each port is 0.28 m/s. This entrance velocity is well under the Ministry's maximum guideline of 0.6 m/s (Ref C-1) (although the configuration of this weir may not be the standard to which the guideline refers).

The placement of a baffle (Plate 13) on the settling tank side of the port combined with the increased flow velocity may contribute to floc shearing in the head of the settling basin.

Each basin is 64.3 m long, 16.5 m wide and 7.3 m deep with a water volume of 7700 m^3. At the various capacities the settling tanks have the following retention times and overflow rates.

	Retention Time (min)	Surface Overflow Rate (m/h)	Weir Loading Rate (m^3/m.d)
Sustained Production Capacity 192 ML/d	173.3	2.51	1080
Rated Capacity 225 ML/d	147.8	2.94	1270
Nominal Clarifier Design Capacity 290 ML/d	114.7	3.79	1640

The Ministry Guidelines (Ref. C-1) suggest that weir loading rates should not exceed 200 m^3/m.d. The existing weir loading rates are 5 to 8 times higher than the recommended

maximum. It is recognized that these are not standard weirs and these loading rates may not be cause for concern. The high rates, however, can affect the velocity profiles in the settling basin and can contribute to short-circuiting and poor solids removal.

MOE guidelines specify overflow rates for sedimentation tanks of between 1.6 and 2.4 m/h (Ref. C-1). At the sustained production capacity the overflow rate is greater than the upper limit suggested by the MOE and may result in less than optimum settling particularly in cold water conditions.

Recent studies by RMOC staff have indicated that plate settlers would enhance settling basin performance and accordingly, this modification has been proposed in the Britannia plant expansion. Operation with the plate settlers installed should allow overflow rates in the range of 3.5 m/h to 5.8 m/h.

Plate 11 shows a pilot tube settler that was also being used in this evaluation. Plate 13 shows the inlet into one of the settling tanks. Section E contains a detailed discussion of the effectiveness of the flocculator/sedimentation tanks.

g) Filters

The filter building contains a perimeter influent duct, 0.91 m wide x 2.16 m deep, and 12 filters (header and lateral underdrain) each 16.5 m long, 8.23 m wide and 1.41 m deep with capacity of 20.5 ML/d. Each filter bed has the following media composition:

Material	Limiting Size (mm)	Depth (mm)
Gravel No. 1	50 - 38	102
Gravel No. 2	38 - 25	102

Gravel No. 3	25 - 12.5	102
Gravel No. 4	12.5 - 4.7	76
Gravel No. 5	4.7 - 2.4	76
Sand No. 1	2.4 - 1.2	51
Sand No. 2	1.4 - 0.35	343
Anthracite	0.95 - 0.82	559

Effective sizes for the sand ranges from 0.48 to 0.52 with uniformity coefficients ranging from 1.2 to 1.4. The effective sizes for the anthracite range from 0.85 to 0.87 with uniformity coefficients ranging from 1.4 to 1.7. This is based on lab analysis at the time of delivery.

Water enters each filter through two 300 x 600 mm Limitorque electrically controlled sluice gates and is distributed over the filters. Flow through the filter is controlled using a BIF model ATF level transmitter in the settled water duct. The transmitter has an input range of 10 to 100 mm and an output range of 21 to 96 kPa. This signal will cause the modulating control valve on the low lift pumps to either open or close depending on the level in the settled water duct. The settled water duct has a Warwick Controls Type 1510M low-level alarm which will close the filter effluent butterfly valve (BIF, 400 mm electric Limitorque) if the level is too low. Water drains from the filters through lateral 80 mm pipes.

Filter rates at the various capacities are as follows:

Sustained Production Capacity	192 ML/d	-	5.4 m/h
Rated Capacity	225 ML/d	-	6.3 m/h
Nominal Filter Design Capacity	290 ML/d	-	8.2 m/h

These values were calculated assuming only 11 out of 12 filters in operation with one in backwash mode. MOE guidelines (REF C-1) allow a maximum filtration rate of 12 m/h. At rated capacity Britannia is well within this range.

Plate 14 shows the filter gallery controls and Plate 15 presents a set of filters and backwash troughs.

Backwash water is pumped from the clearwell back through the filters using two backwash pumps. Each pump has the following description:

Manufacturer:	Worthington Type 20-MCZ-1
Type:	Vertical
Capacity:	64 ML/d
T.D.H.:	8.84 m
Rotational Speed:	585 rpm
Motor:	Tamper Model MVD-844E-1LT, 75 kW, electric

Pump accessories include:

Suction valve:	Crane manual 600 mm
Discharge Valve:	B.I.F. 525 mm butterfly valve with a Limitorque 0.56 kW electric operator which closes the valve in 20-30 seconds
Check valves:	Dominion Engineering 525 mm tilting disk valves, with 7 kPa working pressure

Backwashing frequency is determined by a number of factors. Effluent turbidity breakthrough of 0.5 FTU or 1.5 m headloss indicate the necessity of backwashing the filter. In this process, clearwell water is pumped back through the filter bed at a maximum high rate (127 ML/d) dislodging material originally trapped by the media. Surface wash agitators sweep across the surface of the filter bed in a circular motion to aid the cleansing process. Each backwashing procedure consumes approximately 450 m^3 of treated water

which is discharged into a wash-water trough for subsequent disposal to waste. Total wash-water consumption accounts for 2 - 3% of plant production. At 127 ML/day the high wash rate through a filter is 36 m/h. This creates a bed expansion of approximately 150 to 200 mm or 17% to 22%. The MOE suggests a backwash rate of 45 m/h and a bed expansion of 30% (Ref. C-1). The surface wash agitators are shown in Plate 16.

A detailed description of the backwashing procedure can be found in Section D.4.

h) Clearwell

Britannia's treated water is stored in two clearwells, each with dimensions of 39.6 m long x 29.5 m wide x 4.8 m deep. They have a combined total volume of 10,400 m^3. The clearwell water level is measured by an ultrasonic level sensor in both the north and south clearwells.

The retention times of the clearwell at the various capacities are as follows:

Sustained Production Capacity	(192 ML/d)	-	78 min
Rated Capacity	(225 ML/d)	-	67 min

Clearwell detention times appear adequate for disinfection given that the filtered water pH can be reduced to improve disinfection efficiency. Additional clearwell capacity is being added in the proposed plant expansion.

i) Chemical Mix Tanks

Post-chlorine and fluoride are added into a concrete chemical mix tank. It has a volume of 268.6 m^3 (6 m long x 7.46 m wide x 6.0 m deep). The mix tank provides a retention time of 4 minutes at 192 ML/day and 3.4 minutes at 225 ML/day.

j) High-Lift Pumping (and Diesel Stand-by)

Water is pumped into the distribution system using four electric high-lift pumps with a combined capacity of 230 ML/d. Two diesel pumps are also available with a combined capacity of 186 mL/d. Two of the electric pumps service pressure district 1W at a head of 65.5 m and the other two electric pumps service pressure district 2W at a head of 78 m. Table C.3.1 gives the detailed specifications for the pumps. During hydro restrictive periods in the City, RMOC has an agreement with Ottawa Hydro to use its diesel pumps and generators. Generally this occurs either in the morning and/or early evening.

k) Waste Disposal

There is currently no waste treatment at the Britannia Water Purification Plant. Wash-water drains back into the Ottawa River for disposal. Detailed evaluation of water treatment residue management is provided in the "Waste Disposal Study for the Britannia Water Treatment Plant".

l) Hydraulic Profile for Solids Separation Process

Figure C2 shows the hydraulic profile for the Britannia Water Treatment Plant.

Table C.3.1

HIGH-LIFT PUMPING STATION

DISTRICT	PRESSURE ZONE 1W			PRESSURE ZONE 2W		
PUMP NUMBER	1W1	1W2	1W3	2W1	2W2	2W3
Capacity (ML/d)	95.5	63.3	31.8	90.9	90.0	45.0
T.D.H. (m)	65.5	65.5	65.5	78.0	78.0	78.0
Rotational Speed (r/min)	900	900	1175	900	900	1200
Motor	Ruston-Paxman (Diesel)	Tamper (Electric)	English Electric (Electric)	Paxman (Diesel)	Brown Boveri (Electric)	C.G.E. (Electric
Size (kW)	1175	597	336	1305	1006.7	560
Installed	1961	1961	1961	1961	1961	1978

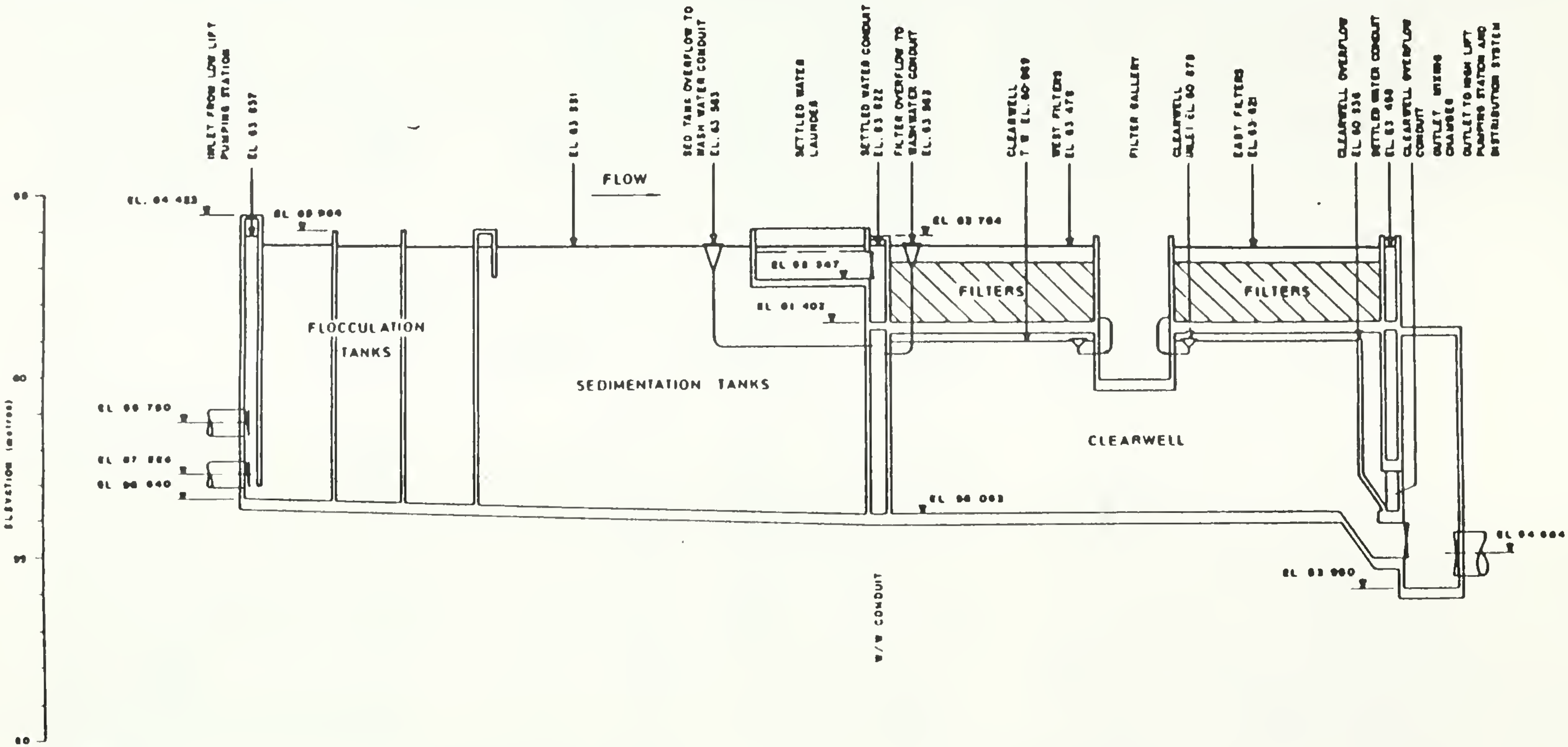


Figure C2

HYDRAULIC PROFILE AT DESIGN FLOW BRITANNIA WATER TREATMENT PLANT

SOURCE : RMOC

C.4 Chemical Systems

a) Disinfectant

Chlorine gas is delivered in 910 kg cylinders. It is presently supplied by the Stan-Chem Business Unit of CIL Ltd. out of Montreal, Quebec. However, the supplier may change on an annual basis, as per the tender process.

Storage

There are usually a total of 22 full and empty cylinders stored at Britannia. Three Fairbanks and Morris scales support a total of six cylinders that are feeding the system at any given time. Plate 4 shows the chlorine tanks on the scales.

Equipment

The six cylinders feed two Wallace and Tiernan Series 50-202 chlorine evaporators and a total of four Wallace and Tiernan V-800 chlorinators. Feed vacuum is provided by adjustable Wallace and Tiernan Model U 160931 injectors. The chlorine system has the following characteristics:

Capacity:	910 kg/d per chlorinator (each evaporator has a capacity of 1140 kg/day)
Feed Ratio:	20:1

Water to the chlorinators is supplied by the plant service. Plate 5 shows two of the four chlorinators.

Application Point

Pre-chlorine is fed at the influent sluice gate in front of the low-lift intake by a vertical diffuser inside the intake well. Post-chlorine is fed at the beginning of the chemical mix tank.

b) Coagulant

Supplier

Liquid alum ($Al_2(SO_4)_3 \cdot 14\ H_20$) used as the primary coagulant at Britannia is presently supplied by General Chemical Ltd. of Montreal. However, the supplier may change annually as per the tender process.

Storage

The liquid alum is stored in a 96.3 m^3 storage tank. This tank feeds a pair of 2.4 m^3 day tanks.

Equipment

The alum is drawn from the day tanks into a pair of BIF Model 65-01 Roto-Dip feeders with a feed rate range of 22 to 8100 L/hr by two feed pumps with the following descriptions:

Manufacturer:	March Model TE-7R-MP
Drive:	560 W Motor @ 575 V, 1.0 Amp
Rotational Speed:	3450 RPM
Controls:	SCR - Beel Controls Model P55-609-00

In 1988 the two transfer pumps will be replaced by Wallace and Tiernan Series 43 metering pumps. Plates 2 and 3 show the Rotodip alum feeders.

Application Point

The liquid alum is carried by plant service water and injected into the intake 6 m in front of the low lift intake well and approximately 800 mm from the bottom of the pipe.

c) Coagulant Aid

Supplier

Activated silica is used as the coagulant aid. Sodium silicate (28%) is presently supplied by National Silicates of Montreal, Quebec. However, the supplier may change annually as per the tender process.

Storage

The sodium silicate is stored in a pair of 13.6 m^3 storage tanks. Plate 6 shows the silicate storage tank.

Equipment

Silica activation occurs when a sodium silicate solution is changed to a pH less than 6. This reaction must be stopped, however, prior to precipitate formation by dilution to a concentration of about 0.002 molar. Acid or chlorine may be used for activation, however due to the availability of alum, modifications were made to the Britannia silactors which allow the use of alum for silica activation.

The alum activation system in the silactors is easier to maintain since the only problem is gel formation in the lines and not crystalline scaling. As well, alum is much easier to handle than chlorine. The volume ratio of alum to silicate fed to the silactor is 2:1. Water from the plant service is also fed at approximately 115 L/hr which gives a water:alum/silicate ratio of 10:1. There are also two sulphuric acid pumps each with a capacity of 1.5 L/min. These are used to automatically clean and flush the silactors every two to three hours.

In 1988, four Wallace and Tiernan Series 44 Duplex metering pumps will be installed, two for sodium silicate and two for alum.

Plate 7 shows a silactor and associated piping. Plate 8 shows the silica feed pump.

Application Point

Activated silica is transported from the silactor through a 40 mm line to a set of distributions weirs directly over the first series of floc chambers. These weirs provide an even flow of silica to each flocculation chamber through a 19 mm line.

d) Fluoride

Supplier

Hydrofluosilicic acid (HFS) 25% is supplied by the Stan-Chem Business Unit of CIL Ltd., Montreal, Quebec.

Storage

The HFS is stored in a pair of 13.6 m³ fibre reinforced plastic (FRP) storage tanks (Plate 25) that feed a single, 450L day tank. The flouride storage tanks do not presently contain a flood storage wall. Catastrophic failure of any of the tanks would result in a release of the HFS.

Equipment

Carrying water is supplied by the plant service and pumped along with the HFS by either of a pair of Wallace and Tiernan metering pumps, to the chemical mix tank. The pumps are controlled by an SCR-Beel Controller which is paced by the high lift summator by adjustment of the transmission between the SCR and the pump. Plate 24 shows the fluoride feed controls.

Application Point

The fluoride/water solution is fed to the chemical mix tank through a T-shaped diffuser on the floor of the mixing tank, much the same as the post-chlorine feed.

e) pH Control

Supplier

Lime (Pebble Quick) is used for pH control of the plant effluent to reduce corrosion problems in the distribution system. The quick lime is supplied by Graybec Ltd., a Division of Jolichaux Ltd., of Montreal, Quebec.

Storage

There are two lime feed systems, each has a 113 tonnes (maximum capacity) dry lime storage bin.

Equipment

Each storage tank feeds a Wallace and Tiernan WC9LM9 Gravimetric Belt Feeder having a capacity of 272 kg/h. Water for the slaker is drawn from plant service and is mixed with the lime at a ratio of 2.5:1. This gives a slurry concentration of approximately 20 g/L. The slurry is pumped by a pair of Wallace and Tiernan type A-758012 slurry pumps, each having a capacity of 110 L/min.

Application Point

Each slaker discharges into a 209 L constant level solution tank. Both these tanks feed a common manifold that splits into 10 of 12 distribution lines to the individual filter effluent pipes for each filter.

C.5 Sampling

The Britannia WTP is provided with sample lines for raw water, filtered effluent (prior to lime addition) and plant effluent. All sample lines are constructed of copper tubing. All sample lines terminate in the plant lab.

Raw water is sampled 22 m upstream of the low lift pumps and is pumped to the lab by a 0.37 KW, 3450 rpm Duro Big Giant centrifugal pump. Filter effluent is pumped to the lab by a 0.25 KW, 3450 RPM Mastercraft centrifugal pump. All pumps operate continuously. Table C.5.1 presents details of in-plant sample lines. All pump impellers and housings are stainless steel in accordance with the requirements of the DWSP program. Section D.6 details the frequency and types of analyses performed.

A sample is also drawn from each filter effluent pipe and used in the filter turbidity scan.

Grab samples are also taken daily and composited for a weekly sample. Section D.6 also contains a summary of grab sample points.

Table C.5.1

DETAILS OF IN-PLANT SAMPLE LINES

Source	Length/Size (m/mm)	Flow (L/min)	Velocity (m/s)	Travel Time (min)
Raw Water 22m upstream of the low lift pumps in the intake line.	110/12.7	4-7.5	0.5-1.0	1.8-3.7
Filtered effluent line prior to lime addition.	10-25/12.7	3-4	0.4-0.55	1-3.5
Plant effluent on discharge side of high lift headers.	90/19 (small amount @ 12.7 mm)	8-10	0.45-0.6	2.5-3.1

C.6 Process Automation

The Britannia WTP is currently undergoing extensive automation which will result in comprehensive computer control over plant operation. Known as the Supervisory Control and Data Acquistion (SCADA) System, it will initially be used for data logging and allow manual control of plant operation from a central system. Eventually control programs will be developed that will automatically perform such tasks as backwashing and chemical dosage adjustments. It is expected that the process control will be in operation by 1989.

C.7 Standby

Britannia has two diesel generators as described in Section C.3(c). Under standby operation (ie. in the case of power failure) one large generator is used to provide power to the low lift pumps and the other is used to provide service to the rest of the plant. There are also two diesel high lift pumps which will provide a total of 185 ML/d. Thus the capacity of the plant is reduced by 40 ML/d under standby power.

C.8. Drawings

a) Site Plan For Britannia

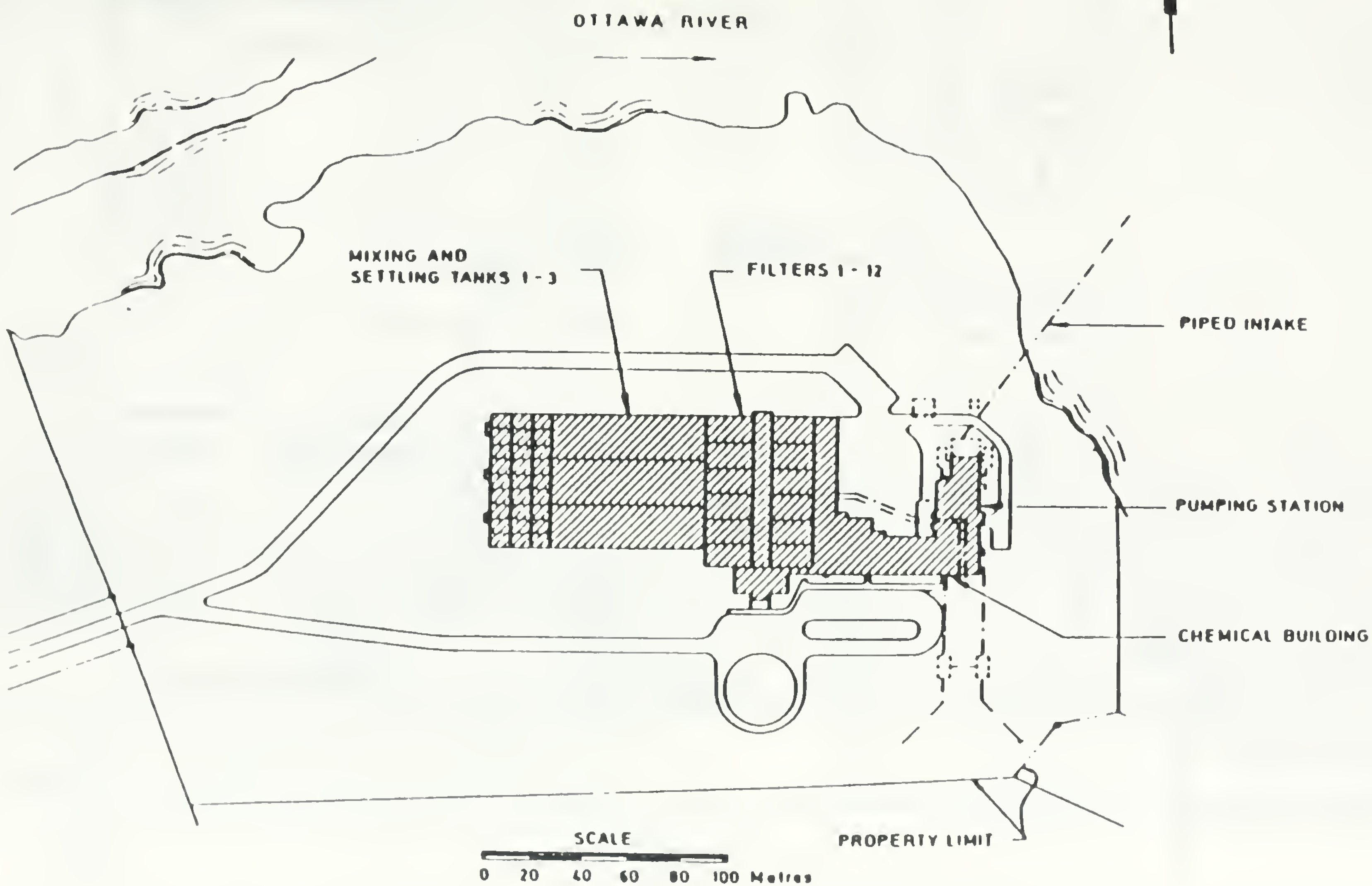
b) Piping and Process Diagram

c) Block Schematic

d) Plates

Figure C3
SITE PLAN

BRITANNIA
WATER TREATMENT PLANT



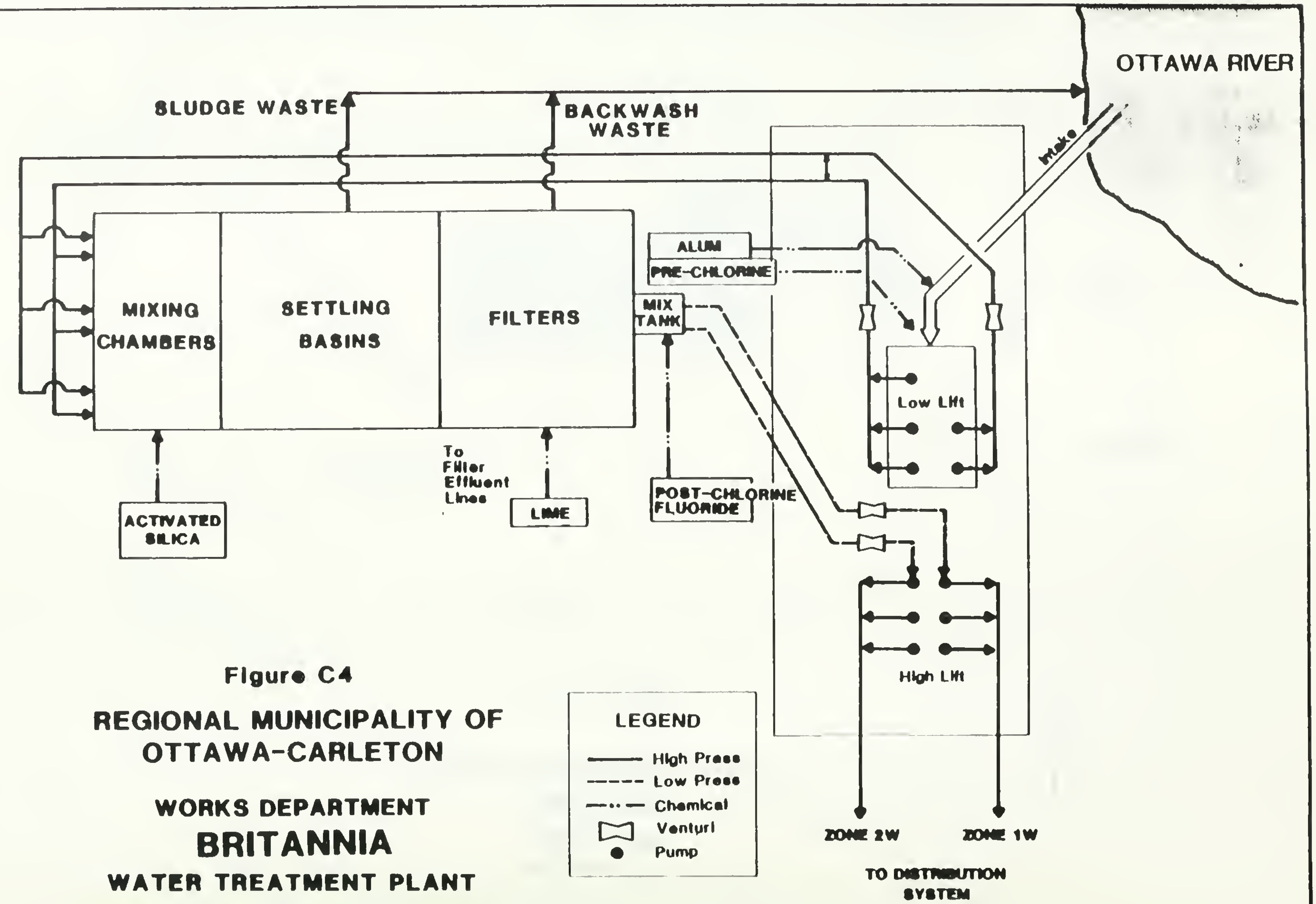


Figure C4

REGIONAL MUNICIPALITY OF
OTTAWA-CARLETON

WORKS DEPARTMENT
BRITANNIA
WATER TREATMENT PLANT
PIPING & PROCESS DIAGRAM

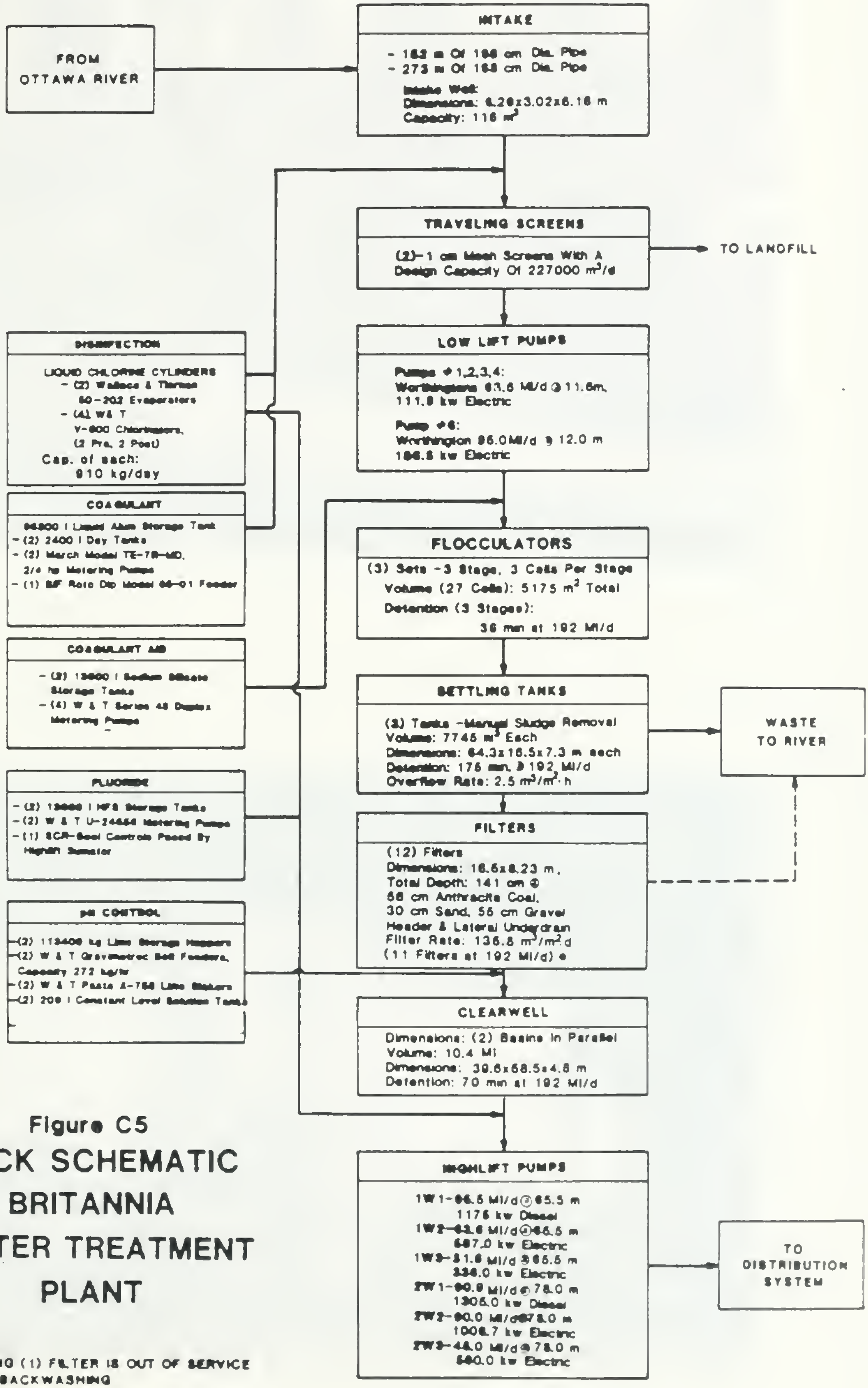


Figure C5

BLOCK SCHEMATIC BRITANNIA WATER TREATMENT PLANT

• ASSUMING (1) FILTER IS OUT OF SERVICE DUE TO BACKWASHING

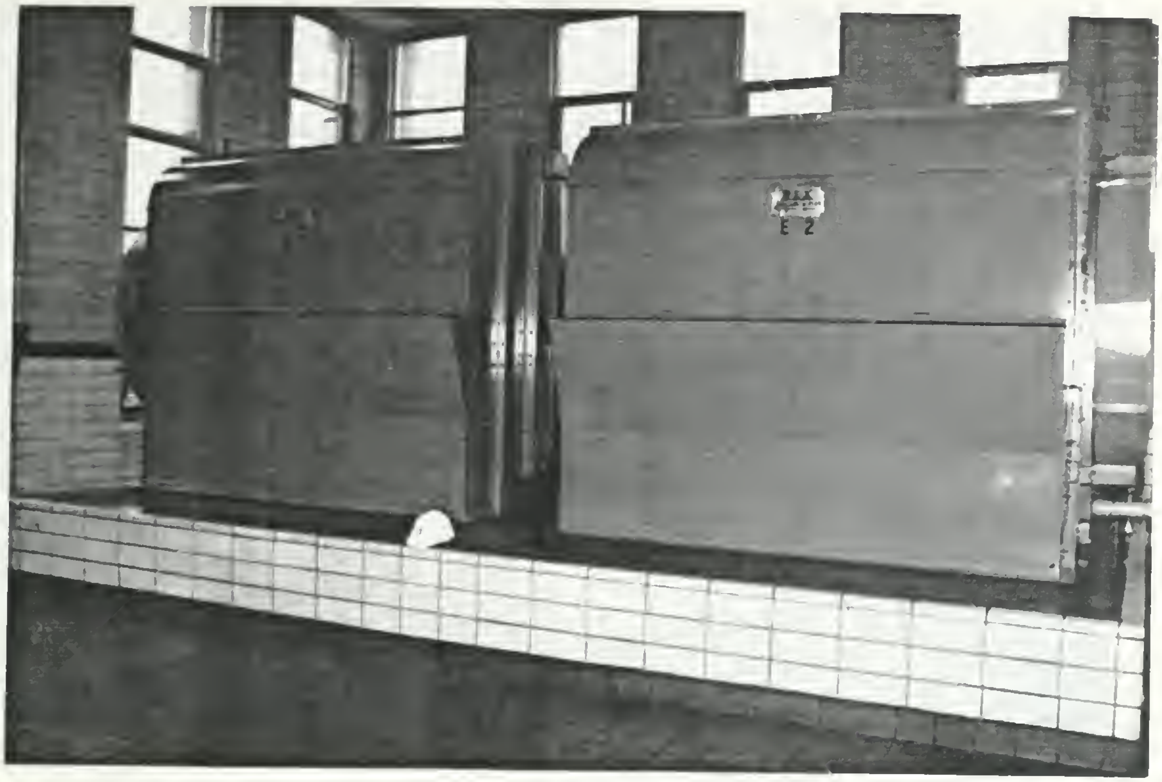


Plate 1:
TRAVELLING SCREENS

Plate 2:
ROTODIP ALUM FEEDERS

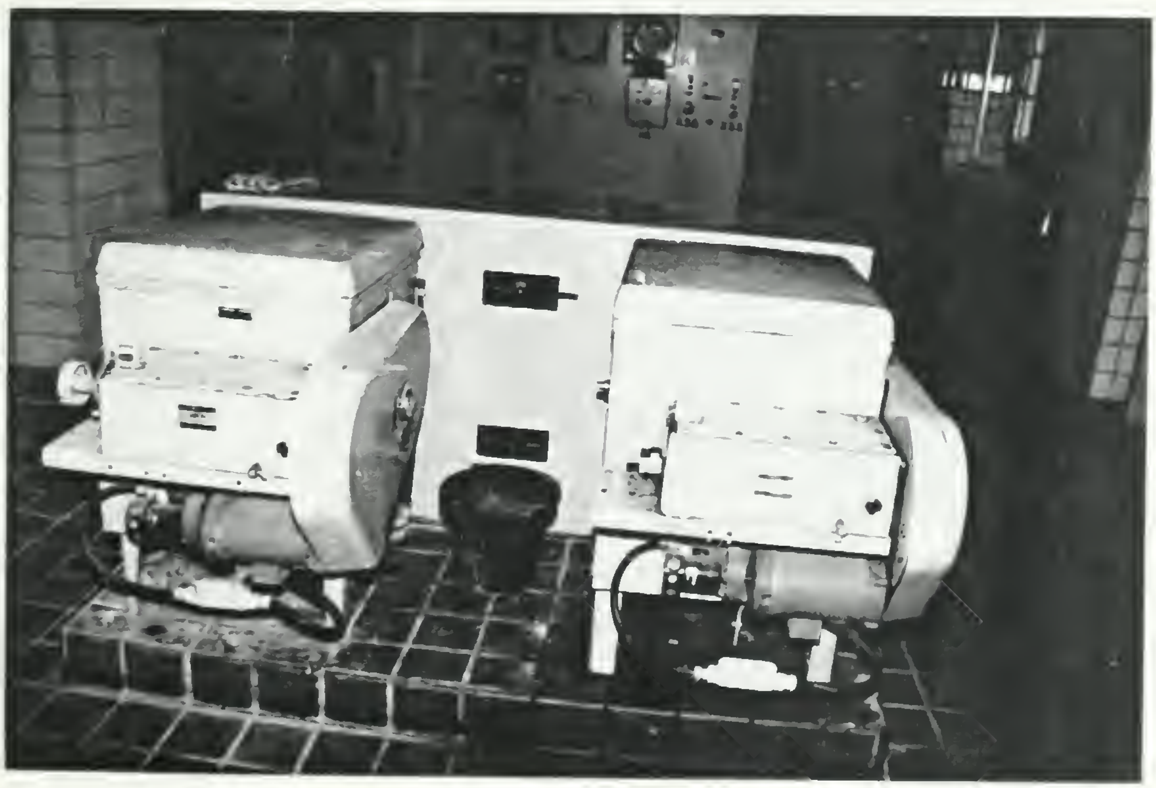


Plate 3:
ROTODIP ALUM FEEDERS

Plate 4:
CHLORINE STORAGE

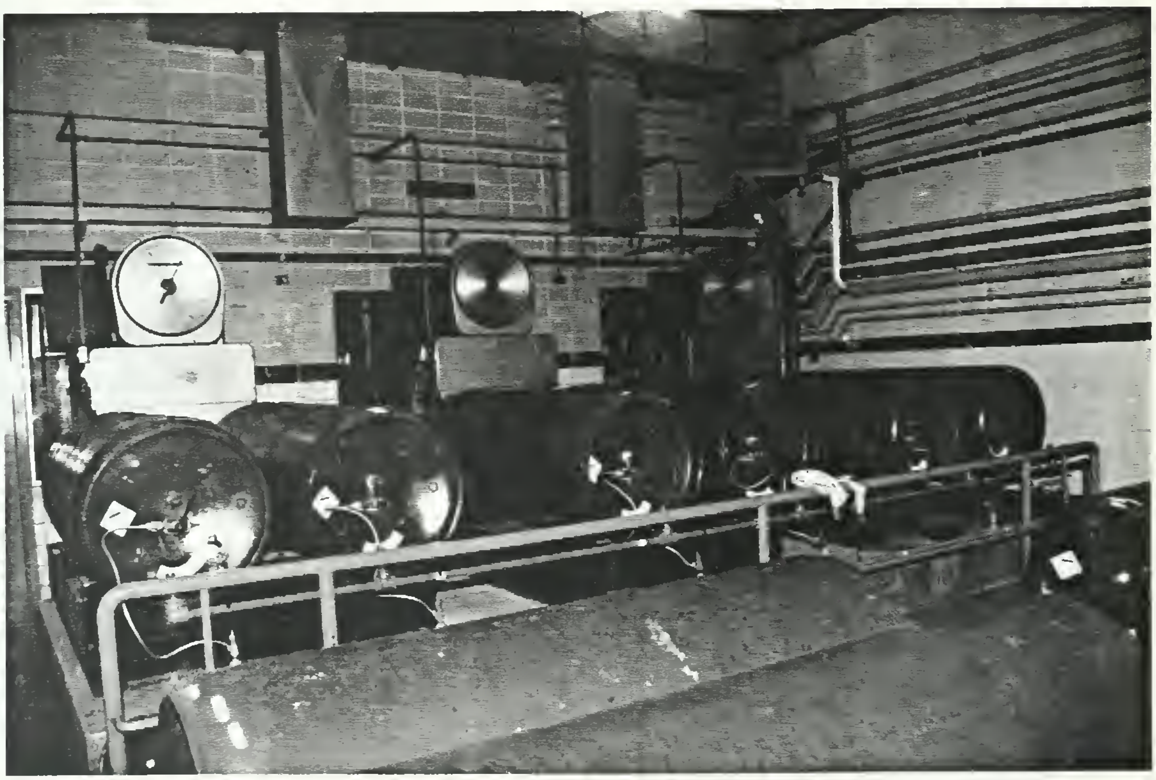


Plate 5:
CHLORINATORS

Plate 6:
SILICA STORAGE TANKS

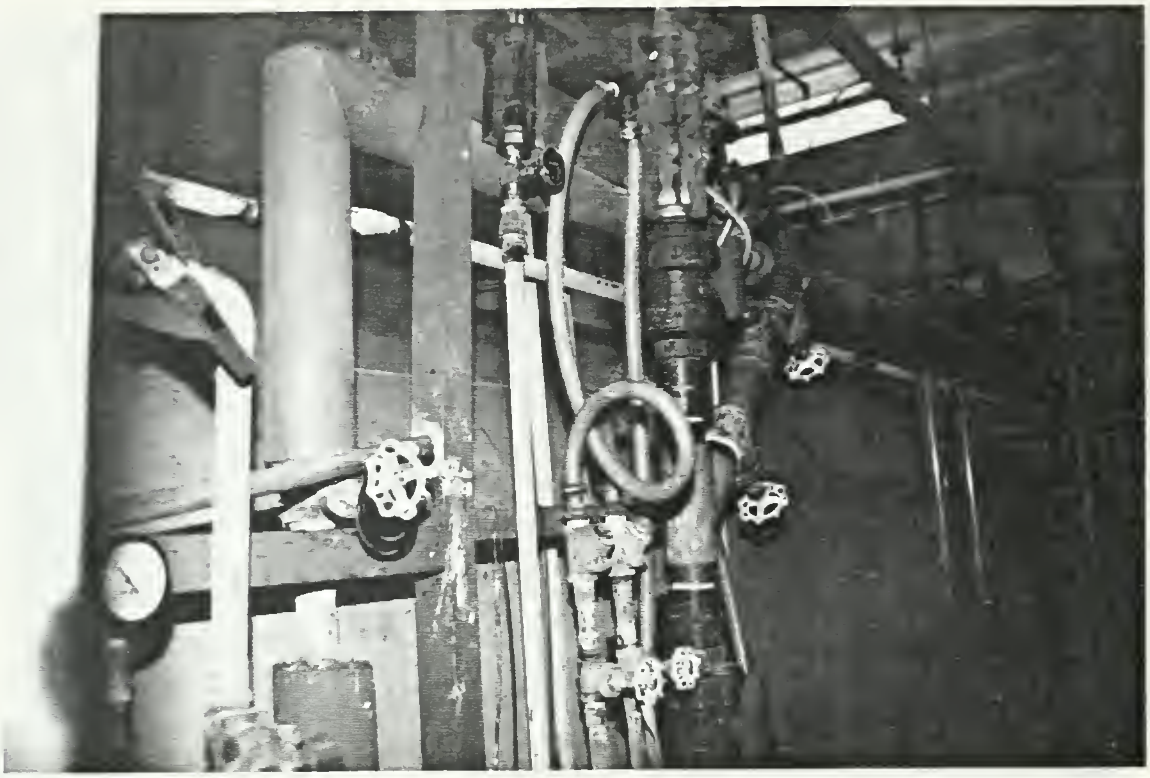


Plate 7:
SILICA FEED PIPING AND SILACTOR

Plate 8:
SILICA FEED PUMP

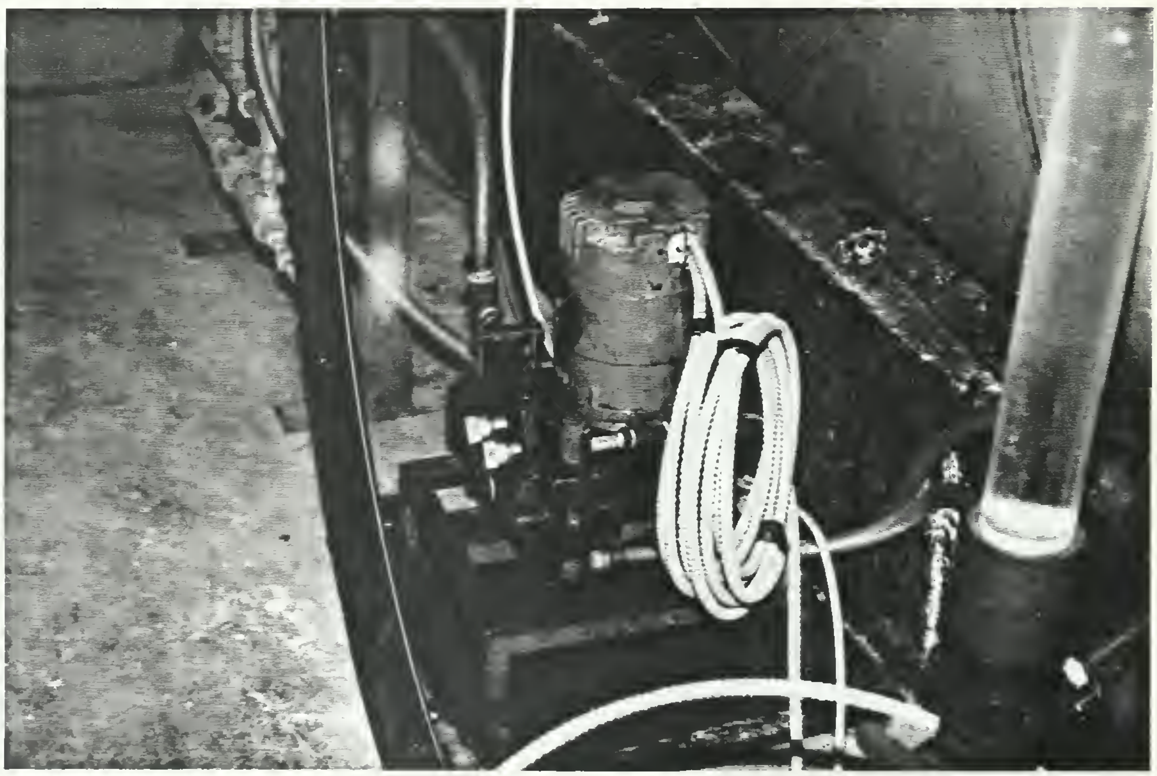


Plate 9:
SPIRAL FLOW FLOCCULATOR

Plate 10:
SPIRAL FLOW FLOCCULATORS

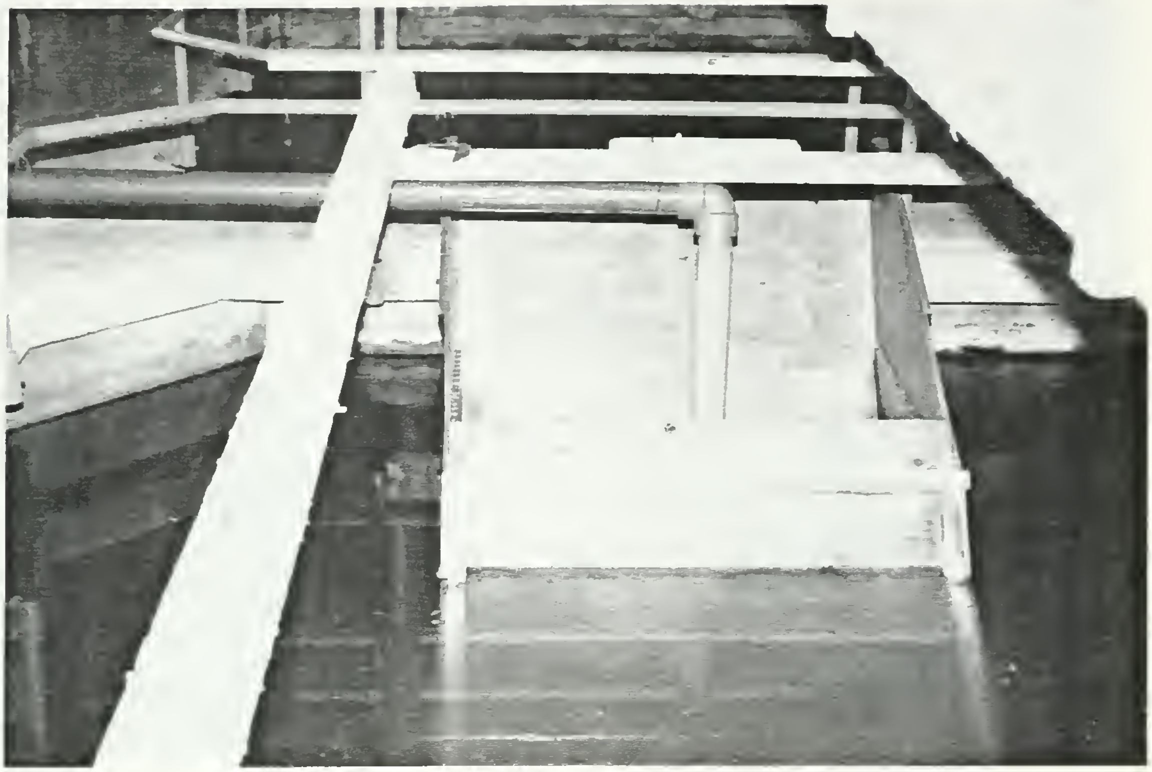


Plate 11:
PILOT PLATE SETTLERS

Plate 12:
SPIRAL FLOW FLOCCULATOR OUTLET

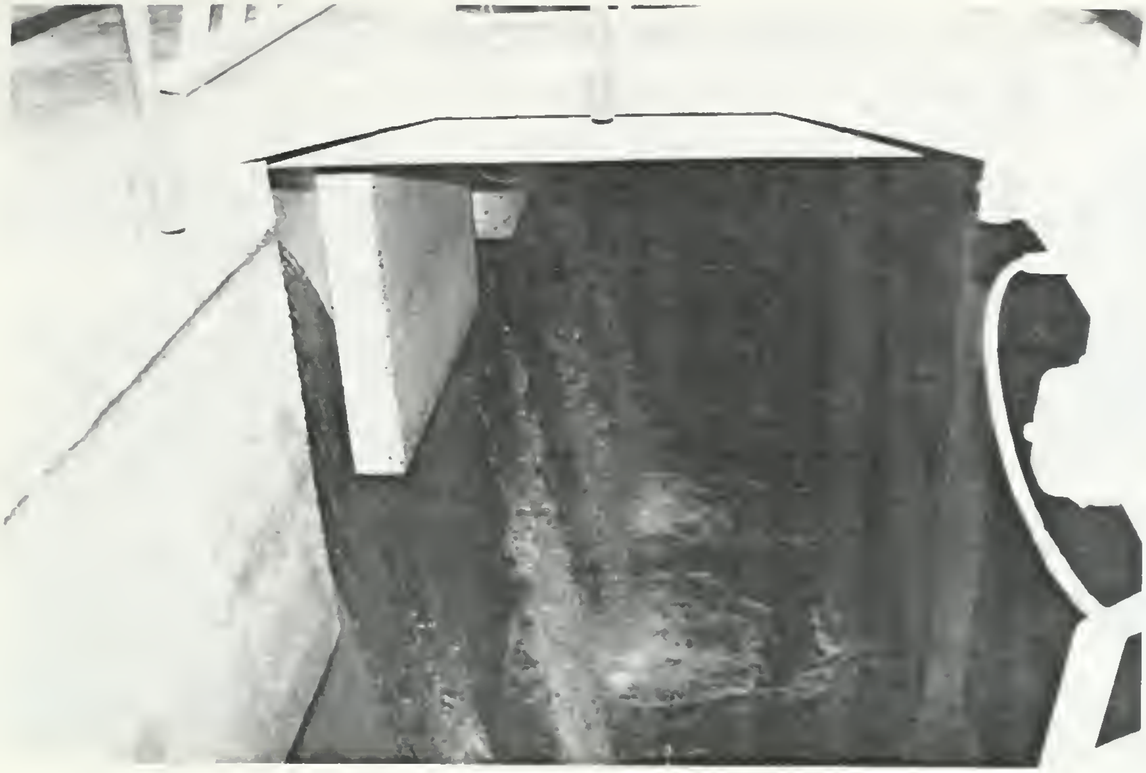


Plate 13:
CLARIFIER INLET

Plate 14:
FILTER GALLERY CONTROLS

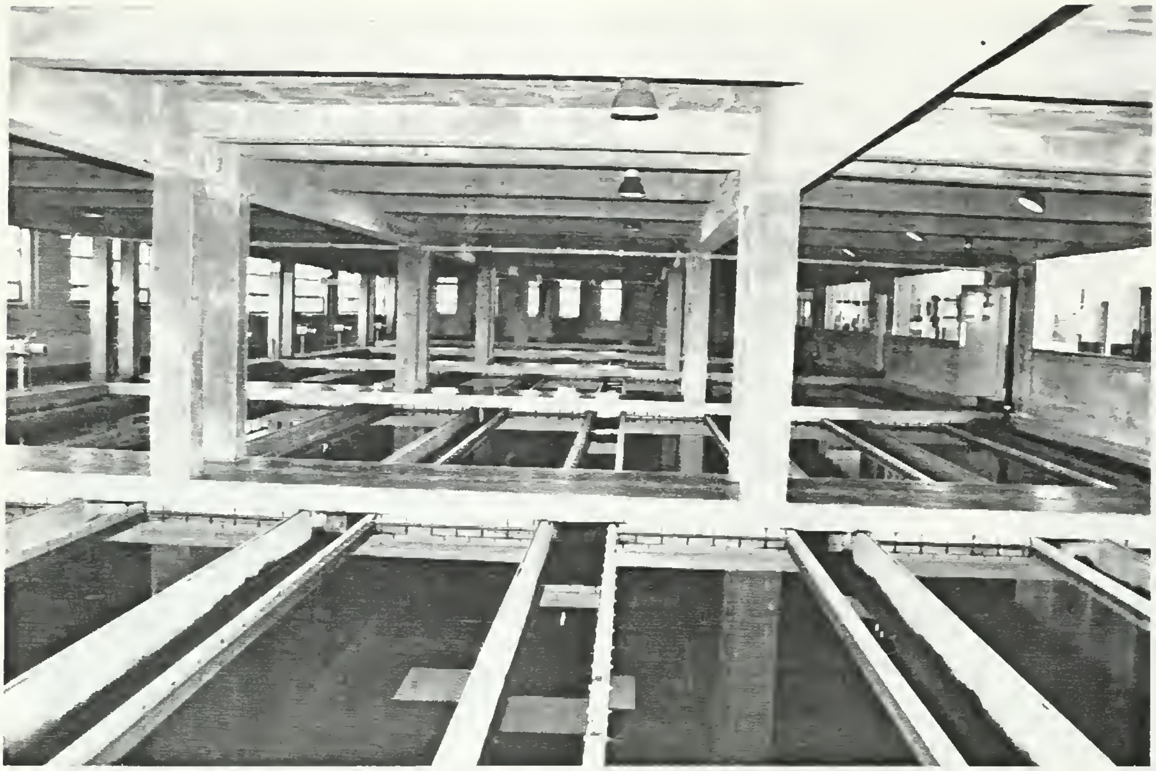
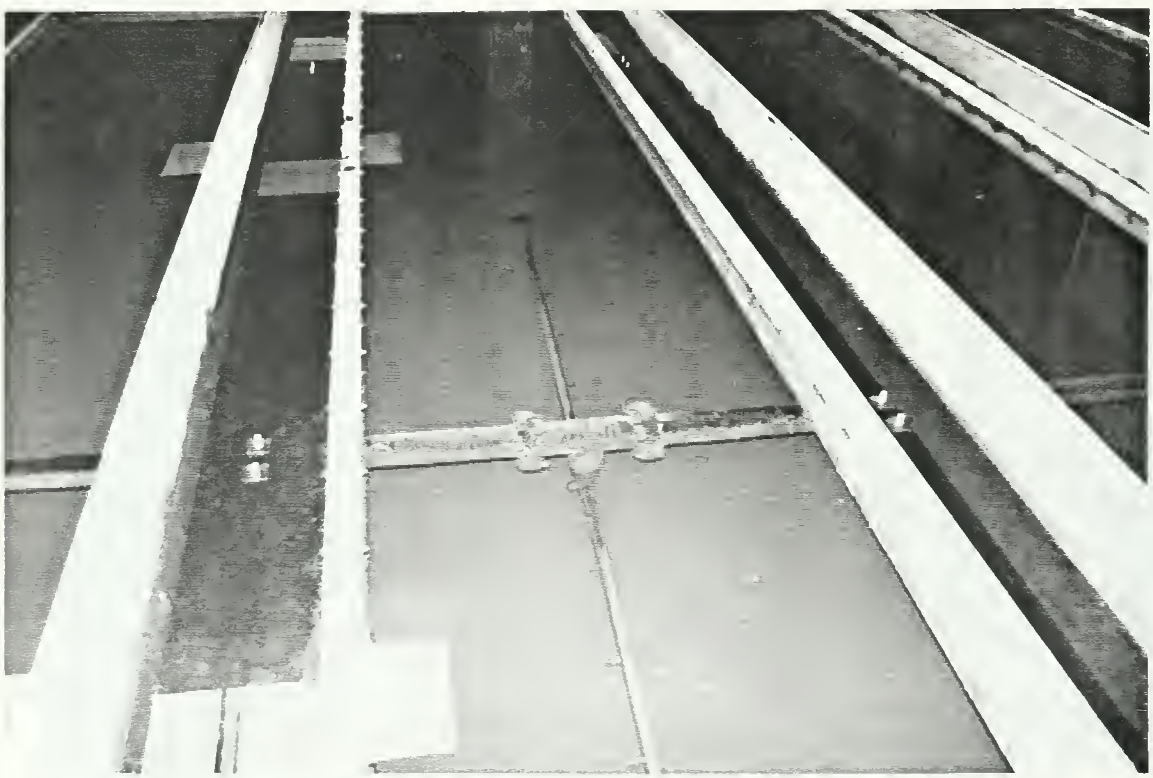


Plate 15:
FILTER GALLERY

Plate 16:
FILTER SURFACE WASHER



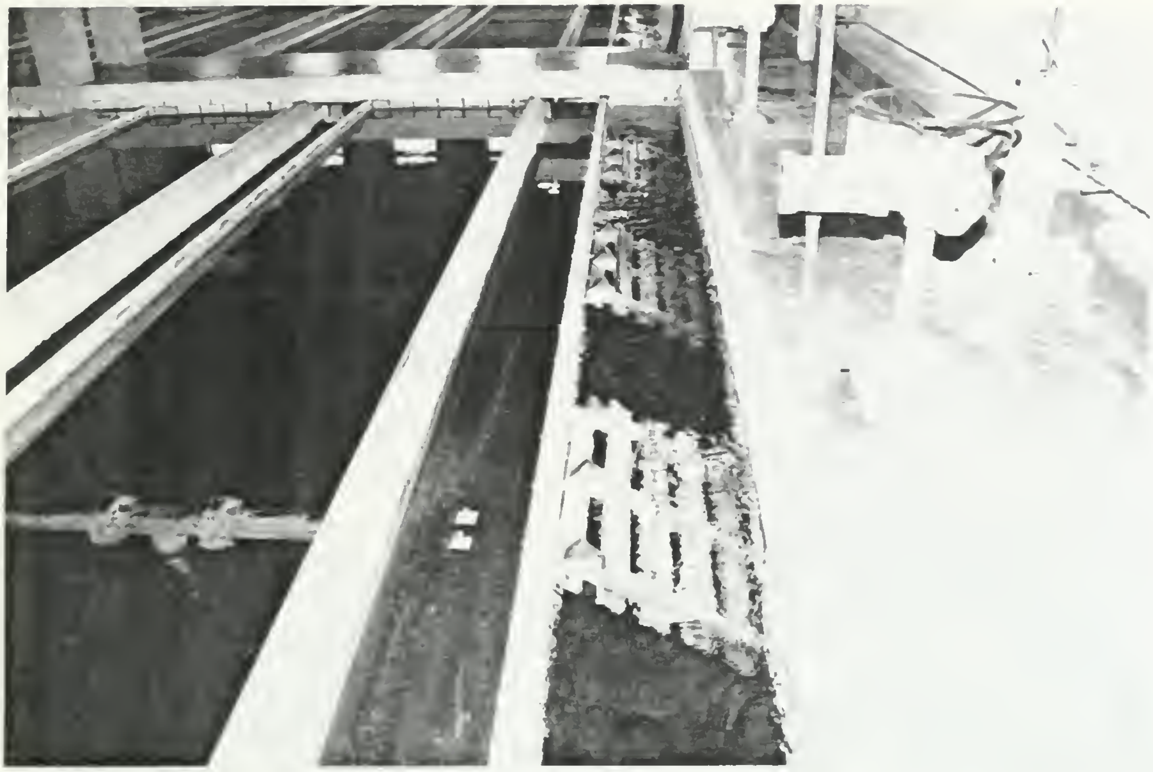
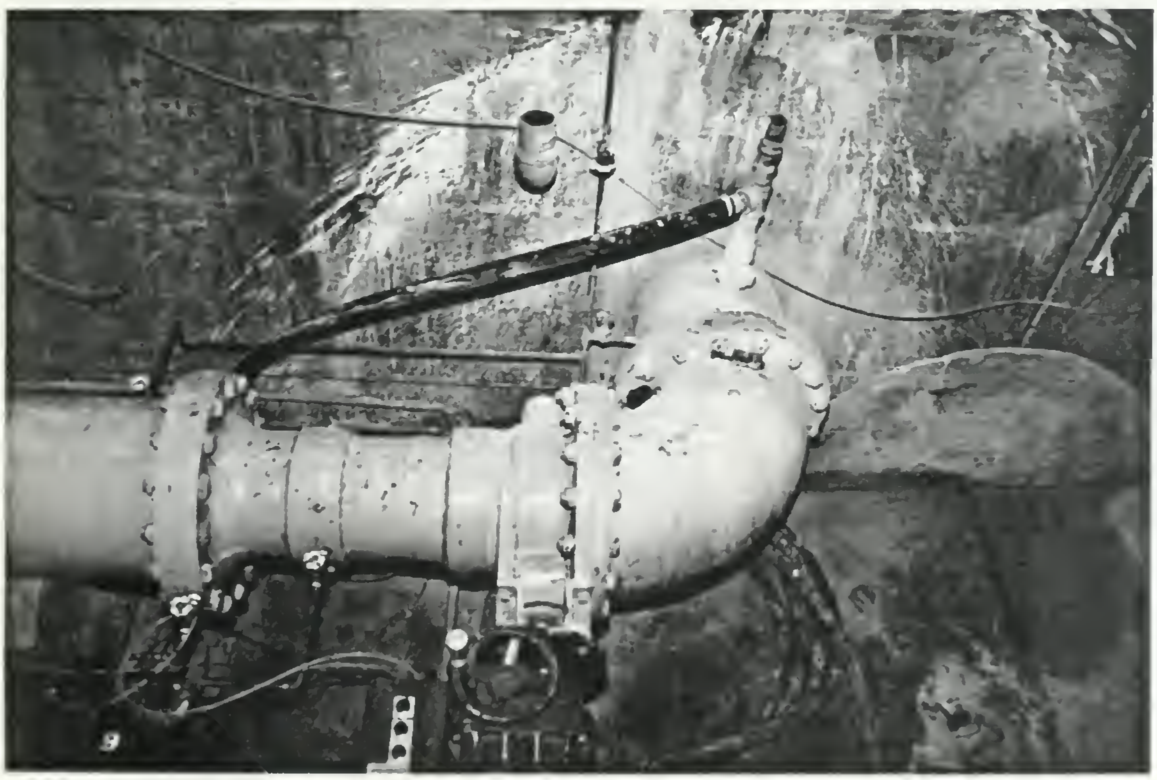


Plate 17:
FILTER INFLUENT CHANNEL INCLUDING BAFFLES

Plate 18:
FILTER EFFLUENT LINES INCLUDING LIME ADDITION



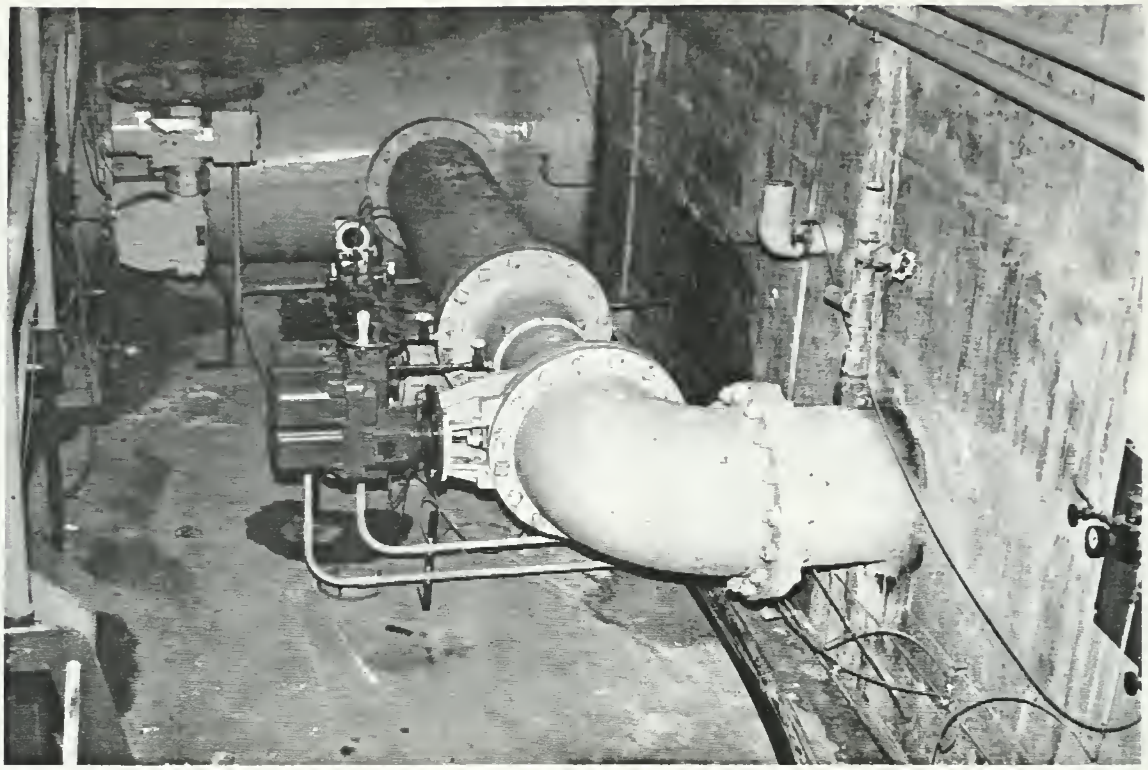
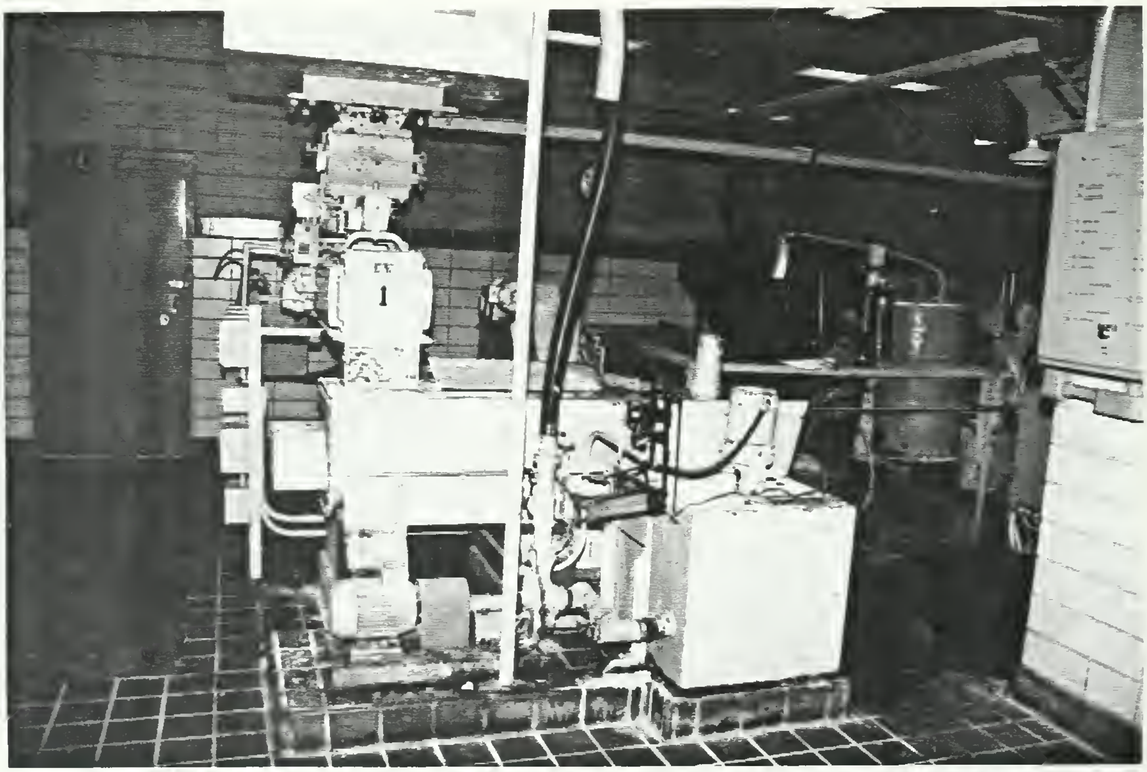


Plate 19:
FILTER EFFLUENT LINE

Plate 20:
LIME FEEDER



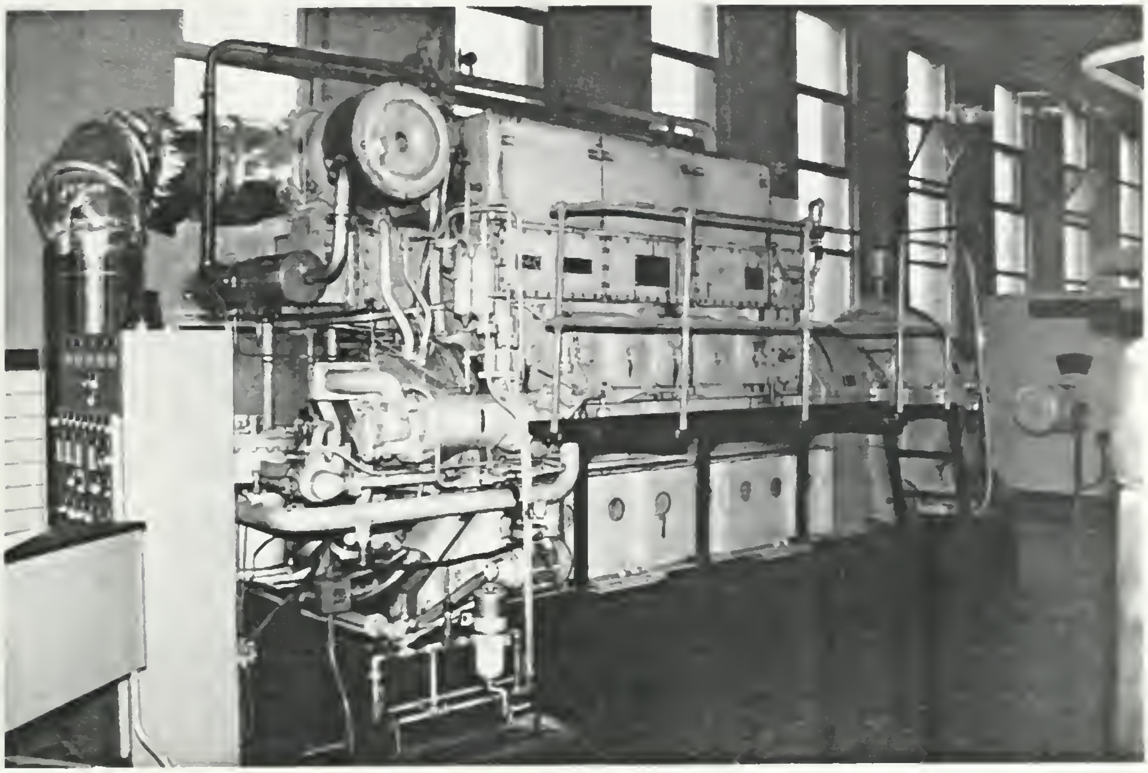
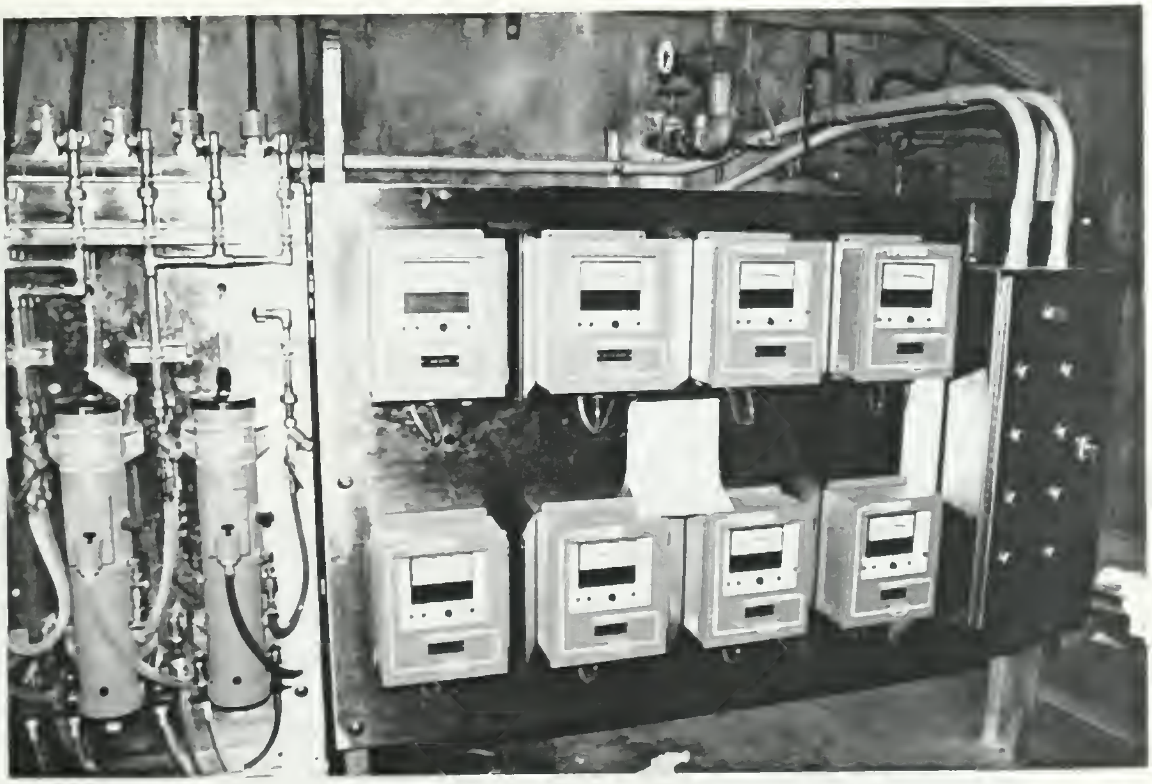


Plate 21:
1W1 DIESEL PUMP

Plate 22:
FILTER EFFLUENT TURBIDITY METERS



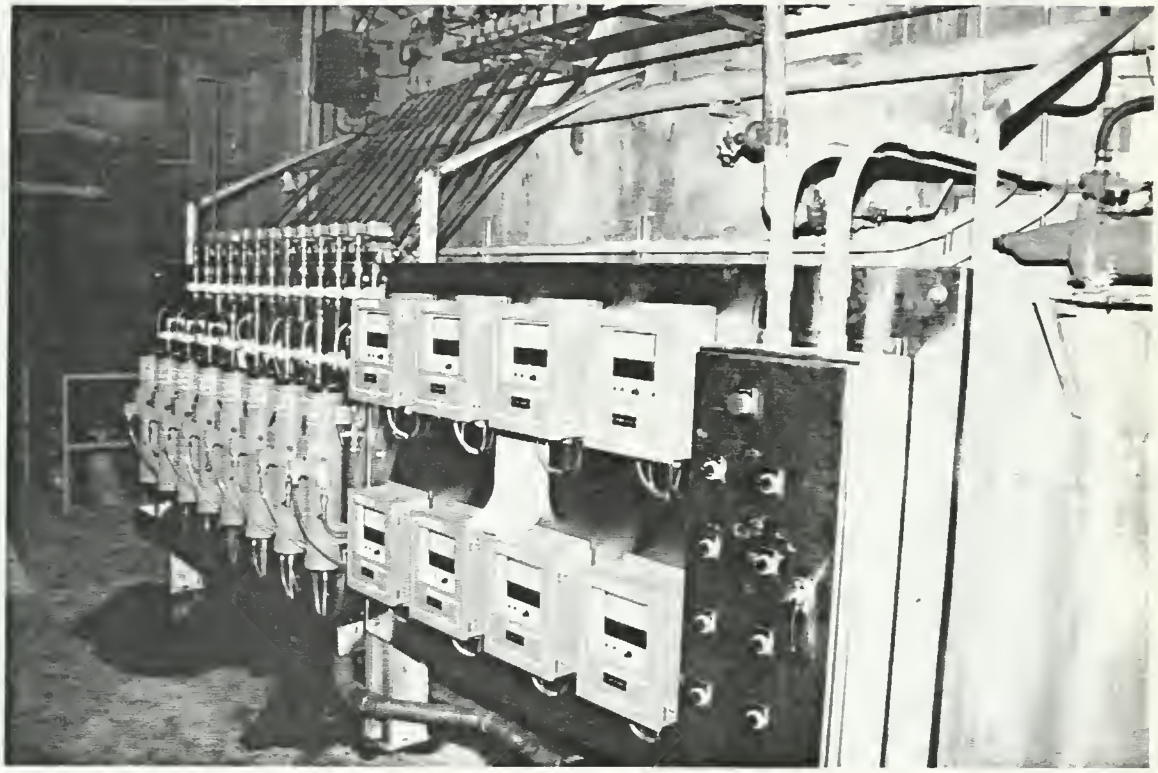
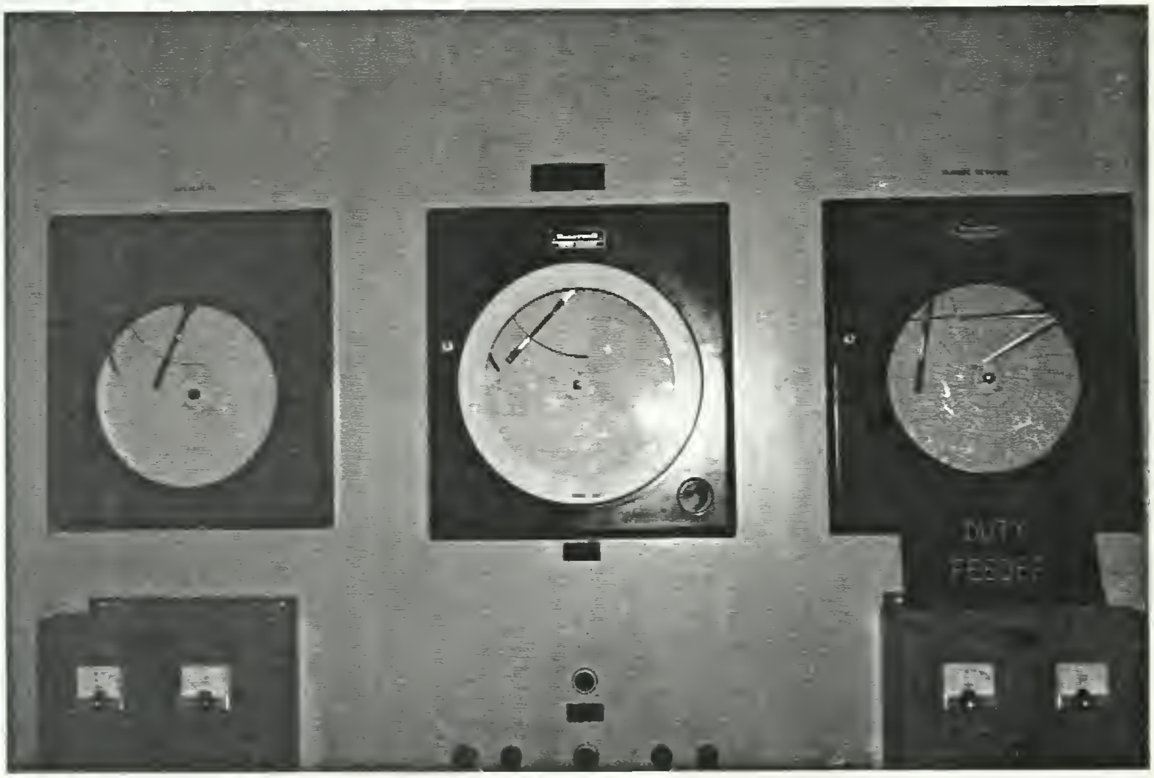


Plate 23:
FILTER EFFLUENT TURBIDITY/METERS

Plate 24:
CHEMICAL FEED CHARTS



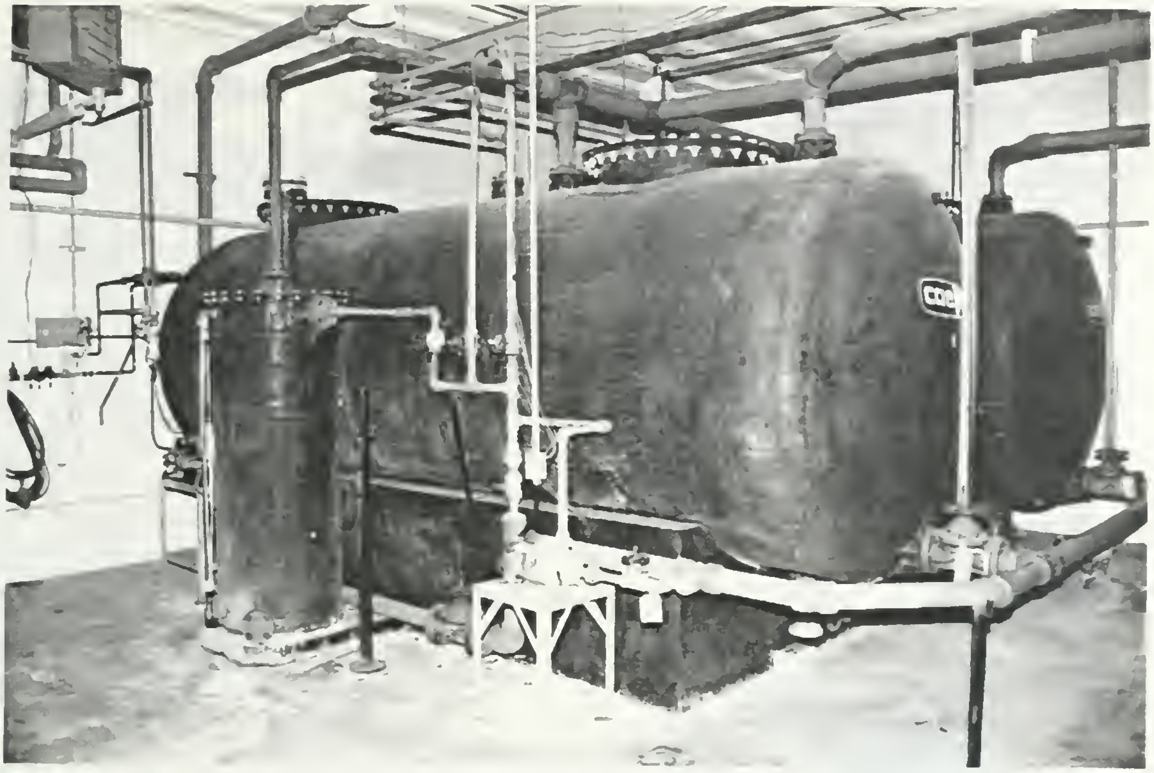
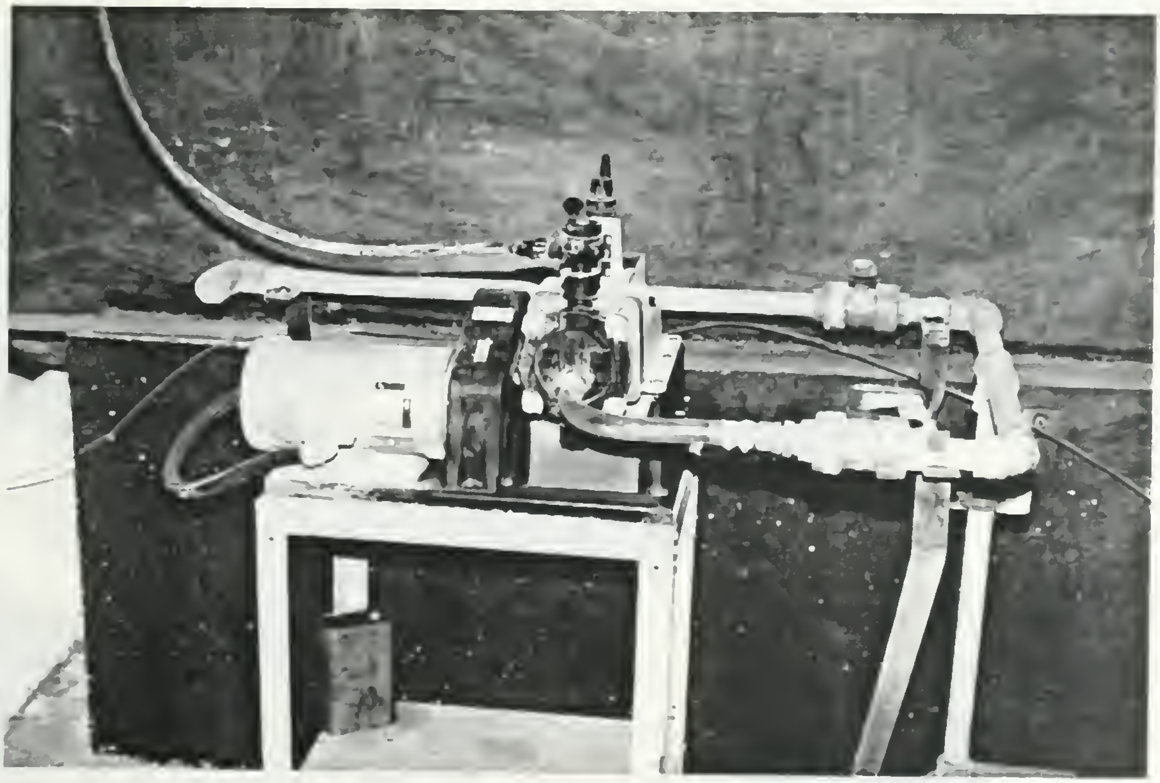


Plate 25:
HYDROFLUOSILICIC ACID STORAGE TANKS

Plate 26:
HYDROFLUOSILICIC ACID FEED PUMP



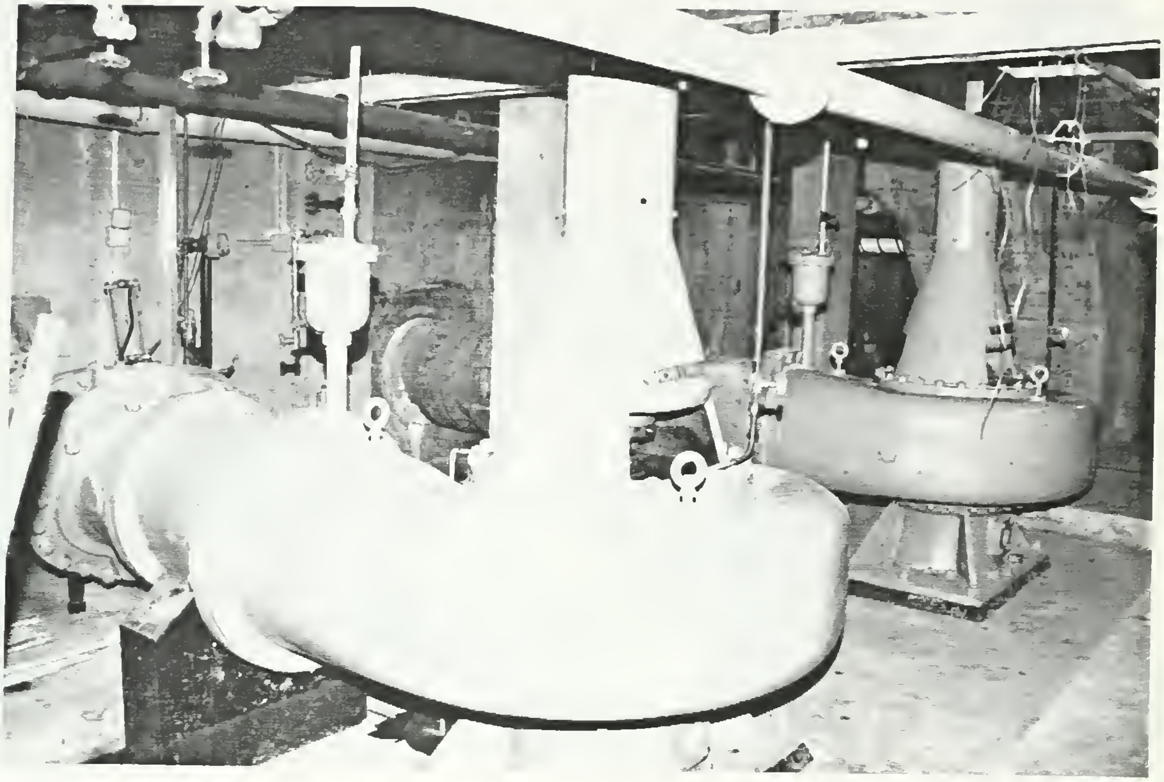
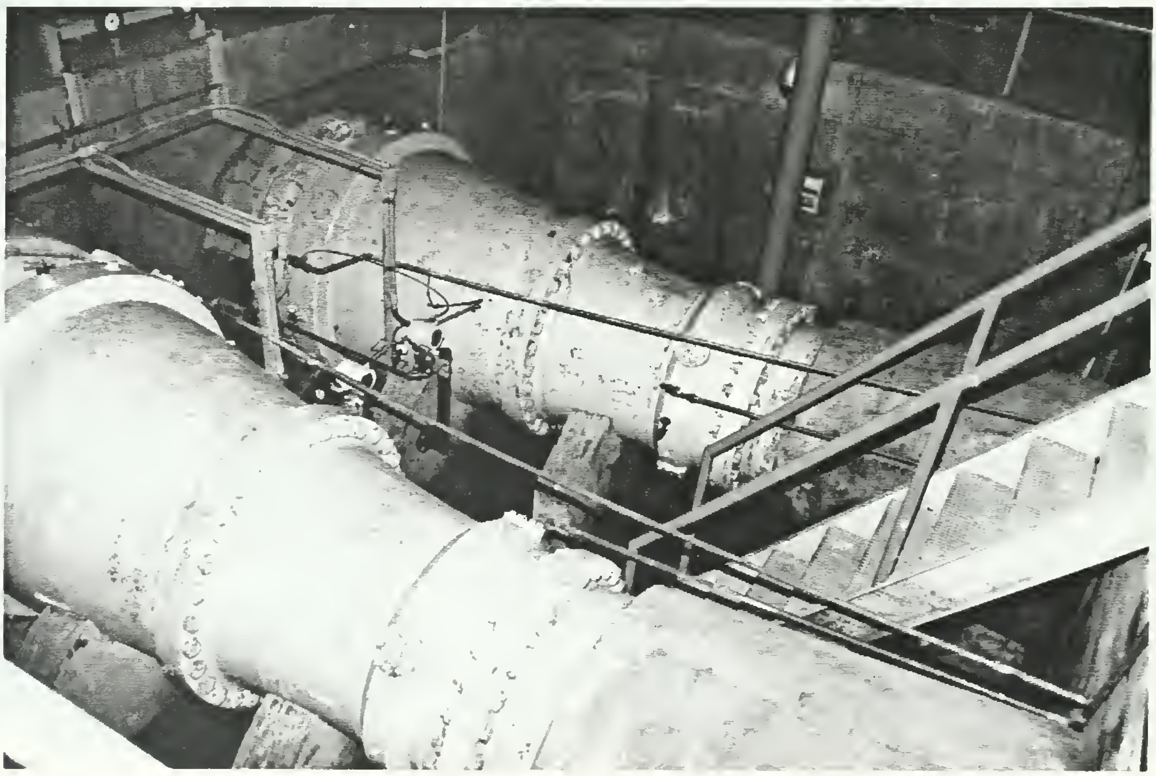


Plate 27:
LOW LIFT PUMPS

Plate 28:
PLANT EFFLUENT VENTURI METERS



C.9 References

C-1 Ontario Ministry of the Environment. Guidelines for the Design of Water Treatment Plants and Sewage Treatment Plants. Toronto, Ontario, 1982.

D. PLANT OPERATION

D.1 General Description

The original Britannia Water Treatment Plant was completed in 1961. It was a continuously operated constant rate facility with a rated capacity of 190 ML/d (rapid sand treatment). In the 1970's the plant filters were converted to dual-media (sand and anthracite). Additional low-lift pumping capacity was added and some modifications were implemented to high-lift pumping. Presently, the plant has a rated capacity of 225 ML/d.

The Britannia plant services both the Central Area containing Pressure Zone 1W and the Western area containing Pressures Zones 2W and 3W. Lemieux Island WTP discharges all of its flow to the Central area. Water is then repumped to adjoining zones (in the Eastern and Western areas).

An analysis of 1983 maximum day demand requirements abstracted from the Region's 1985 Master Planning Study is presented in Figure D1.

The Regional Municipality of Ottawa-Carleton operates the Britannia Water Treatment Plant through the Water Supply Division. The Water Supply Division consists of three branches:

1. Quality Control Branch
2. Operations Branch
3. Maintenance and Construction Branch

The Quality Control Branch is divided into two sections; the distribution system sampling section and the laboratories section.

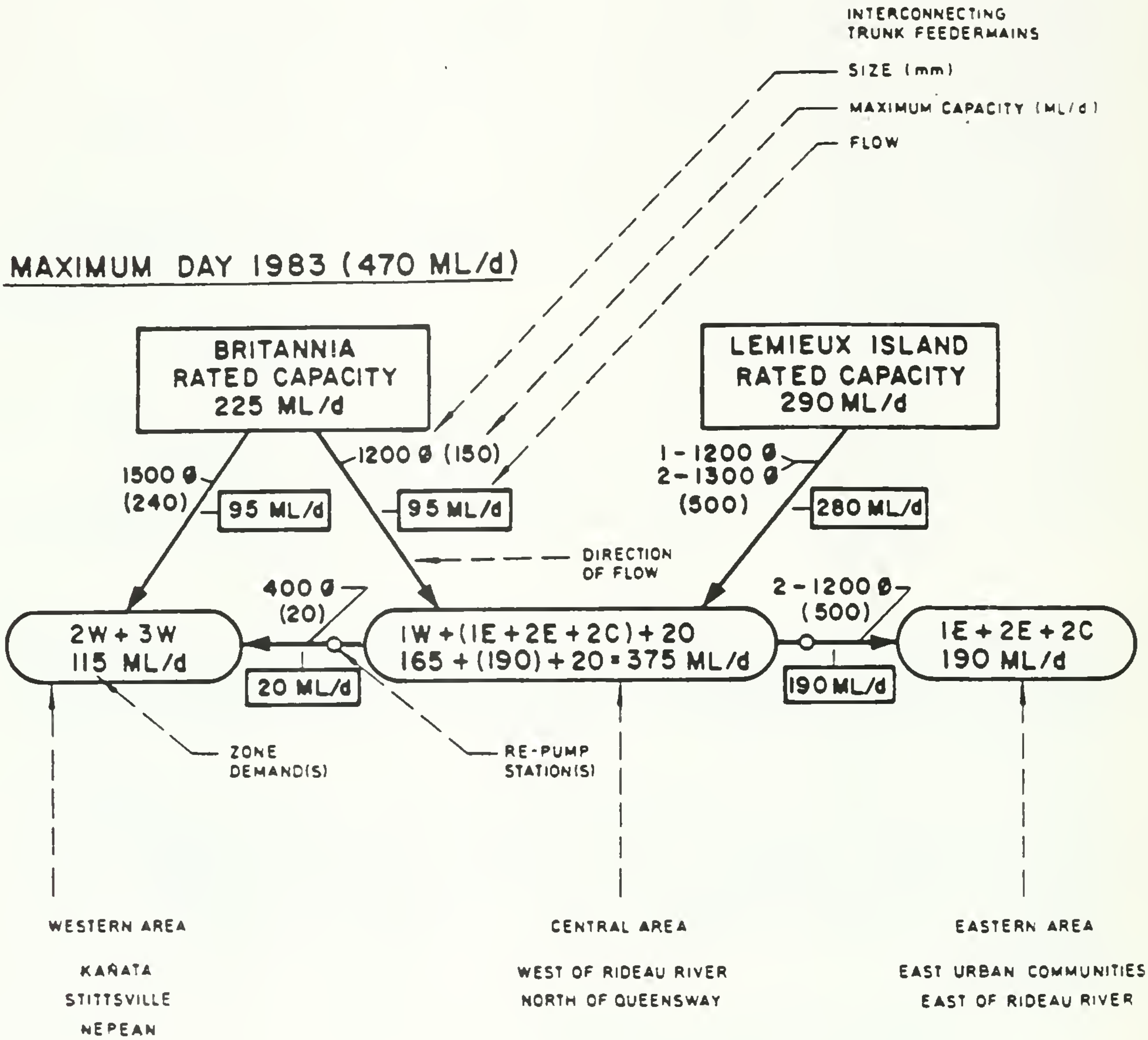


Figure D1

DISTRIBUTION SYSTEM SCHEMATIC

(Source: RMOC Masterplan, 1985)

The Operations Branch is divided into three sections each headed by a plant superintendent. At Britannia the Plant Superintendent heads four operating crews rotating through twelve hour shifts. A crew consists of a shift supervisor, two plant Operators (a Chemical Operator and a Filter Operator) and one floater. The other two sections include the Lemieux Island Operations Section and the System Operations Section.

The Maintenance and Construction Branch is divided into the Electrical and Instrumentation Section, the Mechanical and Structural Section and the Technical Support Section.

D.2 Flow Control

The following is a concise overview of the flow control through the plant.

1. The flow required from Britannia is determined by the System Operator given the various high lift pumping combinations available at the plant. This decision is based on the distribution system storage levels and historical demands.

2. Based on the System Operators plan, the Shift Supervisor at the plant then sets the required combination of high lift and low lift pumps. Currently, all pumps are fixed speed and the number of balanced combinations is limited. For example if high lift pumps 1W2, 1W3 and 2W3 are required to meet the flow required by the System Operator then the required low lift pumps are set to maintain a balanced flow through the plant. In this case it would be #6 low lift plus one pump chosen from #1 to #4. Or any three pumps chosen from #1 to #4.

3. The responsibility to start and stop any low lift or high lift pump rests solely with the Shift Supervisor.

4. All pumps are monitored from the control room adjacent to the pump house.

5. Pumps will shut down immediately under:
   - o Power failure
   - o Thermal overload

   There currently is only a low level alarm in the low lift pump suction well and the low lift pumps are manually shut down when the suction well is low.

6. Filter flowrates are then set to produce the appropriate amount of water. Each low-lift pump is throttled on the discharge side by a valve utilizing a feedback from the water level in the settled water duct. Water level is measured by a Milltronics Model 10L682 open channel ultrasonic level meter.

The clearwell has a high-level override which is a Milltronics Model 10L682 Accuranger which will send a signal to close the filter effluent valves if the clearwell becomes too full. Details of filter operation can be found in Section D.4.

D.3 Disinfection Practices

Gas chlorination is employed at the Britannia WTP for both pre- and post-chlorination. Chlorine solution is injected prior to the low-lift pumps for the pre-chlorination step. Average monthly dosages for the three year period 1984 to 1986 are presented in Table 3.0 while monthly disinfection data characteristic of seasonal variations are presented in Tables 3.1 to 3.3 for the years 1986, 1985 and 1984 respectively.

Pre-chlorination dosage requirements are determined by quality control staff utilizing a daily grab sample of filter influent taken at a standard location. The pre-chlorination residual measurements recorded in the plant log are taken from the in-plant sample tap which draws effluent from the filter effluent ducts prior to lime addition. Samples are taken hourly by the Plant Operator from the mixing chambers to confirm the addition of pre-chlorine.

In the period 1984 to 1986 residuals typically ranged between 0.07 to 0.35 mg/L total residual chlorine (TRC). Dosages necessary to achieve the above residuals were typically 1.0 mg/L in the months January to April increasing to between 2.0 to 3.0 mg/L in the warm weather months. The warm weather dosage requirements reflect the increased warm weather chlorine demand of the raw water.

In the post-disinfection step chlorine water is fed to the chemical mix tank at the outlet of the clearwell. Total chlorine residual is monitored continuously and automatically via an on-line analyzer. The analyzer sample stream is withdrawn via a 12.7 mm copper pipe from the high-lift pump discharge header.

During the period 1984 to 1985 and the first half of 1986 a target total residual of approximately 0.9 mg/L was maintained. The required dosage was generally on the same order of magnitude (plus or minus depending on the residual remaining from pre-disinfection chlorination). In the later part of 1986 (August to December) the post-disinfection dosage was increased to 1.4 mg/L total residual chlorine due to distribution system microbiological problems. A further increase to 1.6 mg/L took place in June 1987.

All chlorine feedrates are manually controlled based on the required residual and plant flowrate.

D.4 Plant Operation

D.4.1 Intake

Ottawa River Water is conveyed to the plant via 425 m of concrete pipe. There is a single 1680 mm gate valve which is closed when inspection and cleaning of the intake and intake well is required. This inspection is carried out by divers approximately once per year and consists of a swim through the pipe from the intake wells to the gate valve.

The intake at Britannia has never been backflushed although the capability to do so exists. The intake does not experience frazil ice problems, although icing does appear on the screens from time to time in the winter.

D.4.2 Screening

The Britannia WTP has two identical travelling screen units. Solid objects adhereing to the screen are physically removed and the screened material is sent to landfill. Both screens are close to 30 years old and are budgeted to be replaced in 1988.

D.4.3 Low Lift Pumps

Screened water is drawn from the low lift suction well by five low lift pumps which discharge into a pair of 1200 mm diameter pipes. Details of pump specifications can be found in Section C.3 (c).

The combination of low lift pumps needed at a given time is determined by the Shift Supervisor based on the high lift pump combination used to provide the plant flow as required by the System Operator. This required flow is based on historical demand (time of day, time of year) but primarily current system storage levels. Low lift pumps are throttled individually by butterfly valves utilizing a feedback signal from the water level in the settled water duct. Details of flow control are presented in Section D.2.

D.4.4 Flash Mixing and Flocculation

The Britannia WTP is not provided with mechanical flash mixing. Alum and pre-chlorine are added approximately 6 m before the low lift pumps. There is some doubt as to the effectiveness of pump impellers providing mixing as is discussed in Section E.

The flocculation process consists of 3 sets of 3 parallel 3-stage spiral flow flocculators. Appendix D contains a detailed description and performance evaluation of the Britannia spiral flow flocculators. Briefly, it was found that the root-mean-square velocity gradients (G) were within guideline values (50 to 10 L/s) during peak summer flow conditions. At other times of the year, the G values were significantly lower. In general the Gt products were much lower than those reported for other spiral flow type flocculators (Appendix Ref. D-13).

The flocculators are generally drained and inspected at 8 week intervals in conjunction with the settling basin cleaning program.

D.4.5 Sedimentation

The spiral flow flocculators discharge into three concrete, rectangular settling basins. The basins are manually

drained and cleaned at approximately 6 to 8 week intervals. The waste generated is discharged directly to the Ottawa River.

Generally, the performance of these sedimentation tanks is consistently good with respect to raw water quality and flow variation. Typically 80 to 90% of the coagulated particles are removed. This is mainly attributed to the considerable length of the tanks. However, the performance of rectangular, horizontal flow settling tanks is dependent upon sufficient retention time and adequate overflow rates under cold water conditions. As will be shown in Section E, the settled water turbidity in the winter is not significantly different from the raw water. This may result from either inadequacies in the flocculators or in the settling basins. Qualitative evidence from the operators at Britannia Water Treatment Plant indicates that less sludge accumulates in the winter than in the summer suggesting poorer performance. This evidence is not conclusive, as the lower winter flow conditions may also result in less sludge accumulation or be the result of smaller floc size.

D.4.6 Filter Operation

The filters operate in two ways - filtering and backwashing. The following section describes the procedures connected with filter control and backwashing. These procedures will form the basis for computer process control.

Filtering

The filters are nominally operated in a constant rate mode. However, when the level of the water in the clearwell is within the top 0.3 m control band, the position of the filter effluent valve is automatically controlled through a

local field system. In this "level over-ride proportional" control situation, changes in clearwell level cause the filter effluent valve to open and close.

When the level in the clearwell falls below this control band level, the filter effluent rate valve position is controlled by the filtration rate set-point. In this mode, the filter will have either an individual set-point or be under "master computer auto rate control" where the same set-point is received by all the filters deemed to be in service by the operator.

An override control engages if the water level in the filters falls below a pre-set "low level" (level probe contacts) and the effluent rate control valve closes. The level must return to a slightly higher pre-set "restart level" (second level probe contact) before filtering is resumed. This ensures that the filter is continuously submerged.

Backwashing

The backwash sequence for the Britannia WTP is depicted in Figure D2. Details of the sequence are presented in point form in the following:

1) The backwash sequence is initiated when there is an effluent turbidity breakthrough of 0.5 FTU or 1.5 m headloss in the filter. A typical filter run is 48 hours. Thus approximately 6 filters are washed per day.

2) The actual backwash procedure is initiated by the closing of the filter effluent valve. Simultaneously, the filtered water turbidity sample solenoid closes and at this point the filter is not incorporated in the effluent turbidity scan cycle. The scan cycle consists of the turbidity measurement of three filter effluents

at any given time. This changes once per hour. The closure of the filter effluent valve is confirmed by zero flow registered on the filter flowmeter.

3) The filter influent gate is closed. The backwash sequence will have a variable pause at this point to allow escape of entrapped air. The length of this pause varies with the season. Generally it is greatest in the spring due to high dissolved oxygen levels where the required pause length may reach 30 minutes.

4) The main filter wash-water supply valve is now opened as well as the surface wash agitator valve.

5) The lead wash-water pump is started and the wash-water control valve opens to a position equivalent to "low rate" which is approximately 45 ML/d. There are 2 wash-water pumps each with their own wash-water control valve. The specific pump sequence (lead and secondary) are operator selectable.

6) The initial low rate wash is carried out for three minutes. It is used to acclimatize the filter to the backwash water and allow even bed expansion. It also allows the surface agitators to get up to speed. At this point the second wash-water control valve starts to open. Both wash-water rate control valves are opened to produce the flow required for high rate wash. This corresponds to approximately 127 ML/d.

7) The high rate wash is maintained for four minutes. Bed expansion at this point is approximately 150 to 200 mm. All wash water is discharged directly to the Ottawa River.

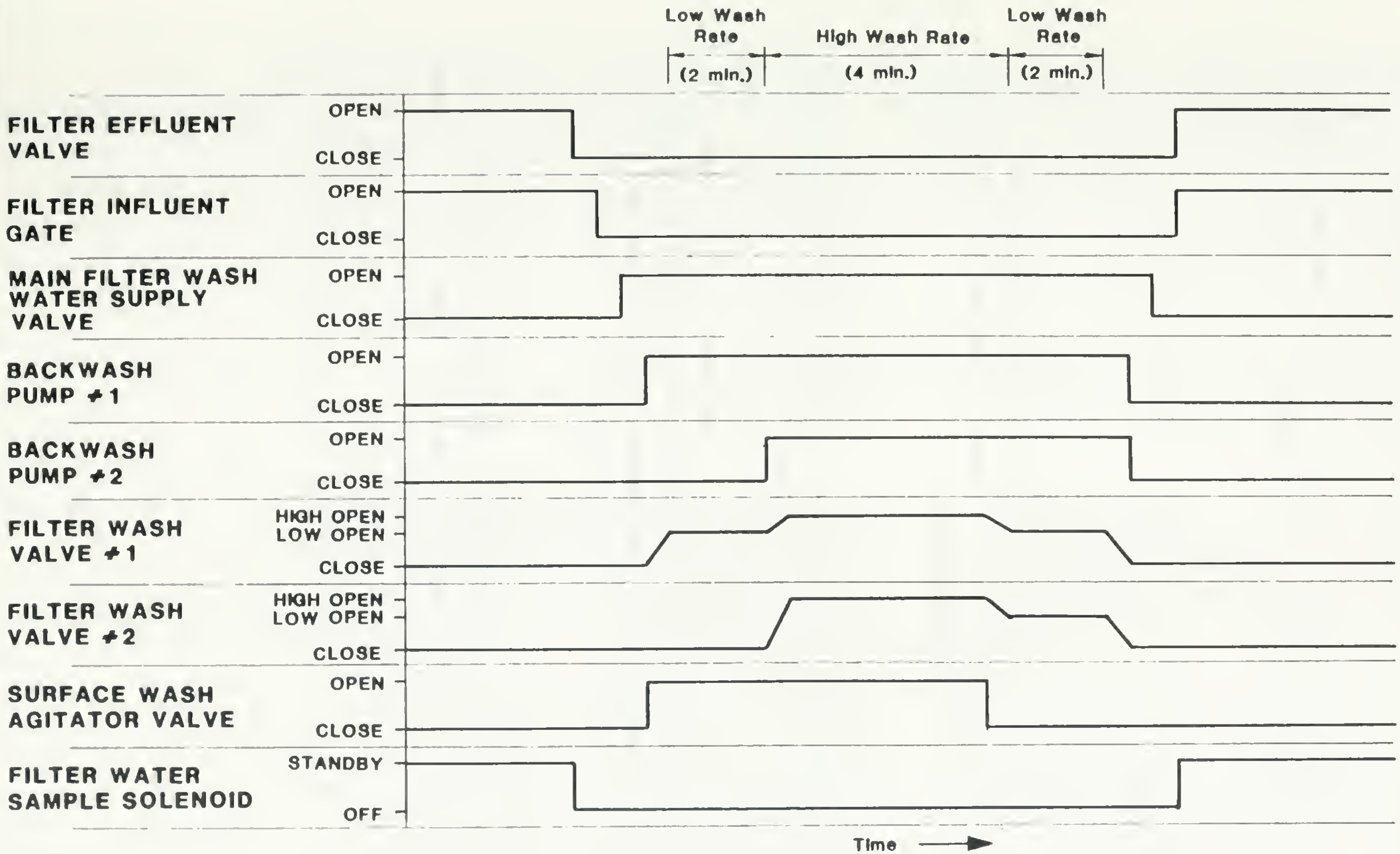


Figure D2
FILTER WASH CYCLE FOR BRITANNIA

8) Following the high rate wash period, surface agitation ceases with the closure of surface wash agitator valve. Both wash-water control valves are modulated to produce a low wash rate for a further two minute period.

9) The wash-water control valves are now throttled closed in a controlled manner and the wash-water pumps are stopped.

10) The backwash sequence is now completed with the following control actions:
   - o closure of main filter wash-water supply valve
   - o opening of filter effluent gate
   - o opening of filter effluent control valve
   - o positioning of the filtered water sample solenoid to the stand-by position

11) After backwashing the filter is brought on-line immediately and no filtering to waste is allowed. Each backwash consumes approximately 450 m^3 of treated water. This corresponds to approximately 3.2 m^3/m^2 per wash which is considered low. However, no problems such as mudballing or increase in clean bed headloss have been observed in connection with filter operation suggesting that the backwash process is adequate.

D.4.7 Clearwell

Cleaning of the clearwells occur approximately once per year using divers. This is required due to the settling of lime fines on the bottom of the clearwells.

D.4.8 Water Stabilization

Lime is added to the filter effluent in order to reduce the aggressiveness of the finished water. However, problems with elevated treated water turbidities were experienced in 1986 due to the appearance of insoluble lime impurities in the plant effluent. This occurred even though most of the insoluble fraction of the slaked lime settles out in the clearwell prior to entry into the distribution system. Reduction of lime addition may not be possible since the pH at $CaCo_3$ saturation is calculated to be between 8.75 and 9.10 depending on water temperature, calcium concentration and alkalinity of the finished water. Therefore, a finished water pH of 8.0 will have a negative Langelier index of 0.75 to 1.1 which means that the water will still be mildly aggressive at current dosages. It should be noted that a pH of 8.0 is not consistent with optimum disinfection practices.

The Regional Municipality of Ottawa-Carleton Water Treatment Master Plan (Ref. E.5) contains a discussion of this problem and two potential solutions. The first solution involved the degritting of the lime. Currently, Quality Control staff are evaluating the effectiveness of a lime saturator which produces a clear lime slurry at a concentration of about 1.5%.

The RMOC Master Plan also suggested an additional alternative; the introduction of limestone ($CaCO_3$) into the water prior to or in conjunction with alum coagulation. This provides additional alkalinity and hardness for aggressiveness control without altering the raw water pH. The limestone can also provide additional surface area which could aid flocculation.

D.5 Chemicals

Chemical dosing requirements are determined by the Quality Control Branch based on a number of variables including: season, plant flowrate, and raw water quality.

Alum is used not only for coagulation but also for pH adjustment of the raw water. Its dosage is based primarily on the amount required to reduce the raw water pH to 5.5 to 6.0 for effective colour removal. Typically a dosage of 26 - 28 mg/L will achieve this objective. At the Britannia WTP the alum feed is automatically flow proportioned and dosage adjustment is manual. Once every half hour the Chemical Operator will check the incoming raw water flowrate and determine the required dosage based on a standard dosage chart developed by the laboratory personnel. The operator will then record the amount of alum fed during the previous half hour and adjust the feedrate based on any discrepency between the amount that was required and the amount actually fed. Confirmation is made by checking the pH levels of the water at the flocculators.

Sodium silicate is used as a coagulant aid once it has been activated with alum. This will occur in one of two silactors as described in Section C.4. Activated silica dosage is manually flow proportioned. Presently a dosage of 0.5 mg/L is used as a coagulant aid at plant flows of less than 135 ML/d. In the summer, dosages range from 0.5 mg/L to 1.0 mg/L depending on the achievable length of a filter run. In the winter, the base dosage is 1.5 mg/L and may increase with high pumping rates. It has been found that too high activated silica doses cause filter runs to shorten due to increases in floc size. Silica dosage control is similar to alum dosage control. Once every hour the Chemical Operator will determine the amount of silica required for a given plant flow based on flow/dosage charts and the amount actually being fed and adjust accordingly.

The Operator will also ensure that the activated silica pH is between 5.5-6.0 to prevent line blockage, and ensure alum activation.

A fluoride ion concentration of 1.0 mg/L is desired in all finished water, year-round. The dosing rate is manually adjusted and the feed rate is automatically paced with the plant effluent flowrate. Residual analysis is performed on by an On-stream Specific Ion analyzer. The sampling system draws a sample from the discharge side of the high-lift pumps and is designed to provide a lag-time of 8 to 10 min. between injection and detection.

Chlorine dosing is based on the demand and desired residual at both the pre- and post-chlorination points. The chlorine residuals desired include 0.1 - 0.2 mg/L in the filter dual media filter effluent and 1.0 - 1.6 mg/L in the treated water. The plant treated water residual is required to meet the disinfection requirements in the distribution system. Chlorine residuals are determined by Wallace and Tiernan continuous total residual chlorine analyzers, and confirmed by manual analyses described in Section D.6.

Lime is added to the filter effluent in order to reduce the aggressiveness of the filtered water. A pH greater than 8.0 is maintained by dosing the lime slurry based on the pH of the plant effluent.

Maintenance and calibration of the above mentioned instruments are described in Section D.6.

D.6 Sampling and Data Collection

Table D.6.1 summarizes the in-plant monitoring program. The plant lab contains three sample taps. Raw water is taken 22 m upstream of the low lift pumps and transferred through 12.7 mm copper tubing to the lab. Filtered effluent water is sampled from the filter effluent line prior to lime addition. The lab tap is cycled between filters through the use of a selection solenoid as chosen by the filter operator. Plant effluent is sampled on the discharge side of the high lift headers and is transfered through a 19 mm inch copper tubing to the lab. Grab samples are also taken at the filter head and influent of the flocculators to evaluate chlorine dosage and residual and monitor turbidities. Additional time weighted composite samples of raw and finished water are taken for daily and weekly analysis.

The pH sample line from the low-lift pumps is flushed on a monthly basis.

Calibration of the residual fluoride analyzer and all pH meters occurs every day. The residual chlorine analyzer and recorder is also calibrated every day or more if required. The turbidimeters are calibrated once per week or as required. Both the zero and span are checked. Maintenance and cleaning of all instruments occurs once per week except for the fluoride residual analyzer which occurs on an as needed basis.

Table D.6.1
BRITANNIA - IN-PLANT MONITORING

Test	Sample Point	Frequency	Testing Instrument
Free Chlorine Residual	Head of Flocculator - grab	Daily	Penwalt Amperometric Titration
	Filter Effluent - lab tap	Daily	Penwalt Amperometric Titration
	Filter Influent - grab	Daily	Penwalt Amperometric Titration
	Plant Effluent - lab tap	Daily	Penwalt Amperometric Titration
Flouride	Raw - composite	Weekly	Specific Ion (Ser 81-020)
	Plant Effluent		
	- lab tap	Daily	WTT Orion Spec Meter
	- Composite	Daily	WTT Orion Spec Meter
	Plant Effluent - online	Continuous	Specific Ion (Ser 81-020)
pH	Plant Effluent		
	- lab tap	Daily	Fisher Accumet (325)
	- lab tap	Hourly	Colour Comparator
	Filter Effluent - lab tap	Daily	Fisher Accumet (325)
	Raw - lab tap	Daily	Fisher Accumet (325)
	Head of Flocculator		
	- grab	Daily	Fisher Accumet (325)
	- grab	Hourly	Colour Comparator
	Raw Low-Lift Header	Continuous	Foxboro-2220 (2)
	Treated Plant Effluent	Continuous	Foxboro-2220 (2)
Residual Aluminum	Treated (grab)	Weekly	LKB Ultraspec

Table D.6.1 (cont'd)
BRITANNIA - IN-PLANT MONITORING cont'd

Test	Sample Point	Frequency	Testing Instrument
Silica	Treated - composite	Weekly	LKB Ultraspec
	Raw - composite	Weekly	LKB Ultraspec
Total Chlorine Residual	Filter Effluent - lab tap	Daily	Penwalt Amperometric Titrator
	Flocculators		
	- grab	Daily	W & T Titration
	- grab	Hourly	DPD
	Filter Influent - lab tap	Daily	Penwalt Amperometric Titrator
	Plant Effluent		
	- lab tap	Daily	Penwalt Amperometric Titrator
	- lab tap	Hourly	DPD
	- on-line	Continuously	W & T Analyzer
Turbidity	Filter Influent - lab tap	Daily	Hach Ratio 43900
	Filter Effluent - lab tap	Daily	Hach Ratio 43900
	Filter Effluent Filtered	8/day	Hach Model 1720
	Raw - lab tap	Daily	Hach Ratio 43900
	Filter Influent Settled	Continuous	Hach Model 1720
	Treated Water		
	- on-line	Continuous	Hach Model 1720
	- lab tap	Hourly	Hach Ratio 43900
TOC/TIC	Raw - lab tap	Weekly	OIC Model 700 analyzer
	Treated Water - lab tap	Weekly	OIC Model 700 analyzer

D.7 Other Water Quality Concerns

Concern for the organic content of water and its combination with chlorine has resulted in the routine use of surrogate parameters for monitoring of organics such as Total Organic Carbon (TOC), ultraviolet, and infrared spectroscopy. Many water plants in Canada, United States and Europe routinely or continuously monitor these surrogate parameters.

No data exists at Britannia regarding ultraviolet absorbance (UVA) on either raw or treated water. TOC analyses were initiated at the Britannia WTP in 1986. On-line monitoring of UVA (which can be used as a rough surrogate of TOC) can provide advance warning of increasing organic concentrations, enabling the operators to adjust chemical feed rates. It was of interest to establish a relationship between TOC and trihalomethane formation potential (THMFP).

Total aluminum levels in treated water have generally been below 100 μg/L in Al although levels as high as 650 μg/L of Al have been recorded. Soluble aluminum is mainly a result of using alum as a coagulant.

Aluminum residuals in the Britannia WTP water are minimized through the use of silica as a coagulant aid and the increase by lime of the pH in the treated water.

D.8 Process Automation

Currently, Britannia is undergoing conversion to the Supervisory Control and Data Aquisition (SCADA) System. Initially this will be used for detailed data logging of plant status and will also allow for manual control of most plant operations from a central point. This is due to become operational by the spring of 1989. Eventually the capability of the system will allow the inclusion of control programs that will automatically perform such functions as backwashing and varying chemical dosages.

D.9 Plant Expansion

An expansion of the Britannia Water Treatment Plant is presently underway. The expansion will include additions of two sets of flocculation and settling tanks fitted with plate settlers, six filters, and a treated water clearwell. The completed expansion will double the present plant capacity.

D.10 Daily Operator Duties

At the Britannia Water Treatment Plant each shift consists of a Shift Supervisor, one Filter Operator and one Chemical Operator.

The Filter Operator is responsible for monitoring filter operation and performing backwash routines. Once every half hour the Filter Operator will record filter effluent turbidity, colour and loss of head. Once every hour the Filter Operator will do the following:

Sample	Tests
flocculator water	pH, alkalinity, chlorine
raw water	turbidity, alkalinity, conductivity, chloride
silica feed	pH

The Chemical Operator is responsible for all chemical systems in the plant. Once every half hour the Chemical Operator will walk through the plant and perform the following functions:

- o check to ensure each piece of equipment is functioning properly
- o record feeder rates and recorder values
- o look for problems in the feeders
- o performs a comparison of plant effluent chlorine to recorder indicator to ensure proper recorder function
- o makes manual adjustments for chemical dosage and flow changes as required

E. PLANT PERFORMANCE (PARTICULATE REMOVAL)

E.1 Turbidity Removal

(a) General

The World Health Organization (Ref. E-1) provided an excellent summary of the history of turbidity as a water quality parameter and the causes of turbidity. The measure of turbidity determined by the degree of light scattering relative to the axis of a light source is given as formazin turbidity units (FTU). Turbidity determined by a turbidimeter which measures light intensity perpendicular to the light axis is presented as nephelometric turbidity units (NTU). Results presented in this study are reported as formazin turbidity units (FTU).

Turbidity can be caused by a wide range of particle types and sizes suspended in the water column. Particles can range from inorganic soil particles and organic vegetable matter to microorganisms, macromolecules and microscopic fibres.

The significance of turbidity as a water quality parameter is related to the following concerns:

- o protection of microorganisms from the effect of disinfectants
- o adsorption of microorganisms
- o source of nutrients to some microorganisms
- o source of taste and odour problems
- o formation of organometallic complexes
- o adsorption and concentration of undesirable priority pollutants
- o a measure of the performance of liquid-solid separation processes

The principal water treatment processes used for removal of particulate matter are coagulation/flocculation, sedimentation, and filtration. Chemically pretreated surface water followed by well designed and operated rapid sand filters can routinely produce filtered water of less than 0.2 NTU (Ref. E-2).

(b) Treatability Testing

The standard method of assessing the treatability of a surface water for particulate removal is by means of jar testing using the standard Phipps and Bird, Inc., 6-place, paddle-stirring apparatus (Ref. E-4). Occasionally the supernatant is passed through a paper filter or bench-scale sand filter to estimate the overall removal efficiency. However, a more usual objective is minimizing residual turbidity in the settled jars. The method described in Ref. E-4 is one of the best available for jar testing for the following reasons:

- provides rapid estimate of coagulant dose
- allows evaluation of floc strength
- permits calculations of the root-mean-square velocity gradient
- the settling velocity of the floc can be quickly estimated

Currently, jar testing is rarely performed at Britannia since alum dosage is based on the required pH adjustment for optimum colour removal. However, considering the excellent performance of the plant, this is a minor point under existing circumstances.

(c) Plant Performance

The data contained in Table 2 (Appendix A) was summarized for the raw, settled, and filtered water turbidities for the

months of January, May, July and October in 1984, 1985 and 1986. The summary is:

Turbidity (FTU)

Date		Raw		Settled		Filtrate		Overall Removal
Year	Month	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	%
1986	January	1.4	0.38	1.4	0.24	0.1	0.03	93
	May	2.4	1.2	1.3	0.65	0.2	0.08	92
	July	1.2	0.22	0.8	0.15	0.1	0.03	92
	October	1.7	0.56	1.2	0.56	0.1	0.09	94
1985	January	2.2	0.36	1.3	0.17	0.1	0.08	96
	May	3.0	0.77	1.4	0.33	0.2	0.05	93
	July	1.2	0.24	0.9	0.37	0.2	0.05	83
	October	1.2	0.30	1.2	0.32	0.1	0.05	92
1984	January	1.6	0.42	1.4	0.30	0.1	0.08	94
	May	3.6	0.70	1.7	0.70	0.05	0.03	99
	July	4.1	1.4	2.0	0.87	0.2	0.04	95
	October	1.8	0.47	1.4	0.43	0.05	0.02	97
Mean		2.1		1.3		0.13		94

In conjunction with the summary of turbidity removals, it is of value to consider the trends in flows through the plant as follows:

	Flow, ML/d		
Year	Maximum	Minimum	Mean
1986	186	63	133
1985	193	98	126
1984	193	6.2	114
1983	192	22	110

Clearly the trend is towards increased plant flows. It should be noted that the low minimum flow rate in 1984 was a result of the plant being out of service for a few days in December of this year due to a fire.

Examining the overall turbidity removal efficiency at the Britannia Water Treatment Plant, it can be seen that

the plant is consistently capable of producing filtered water with turbidities less than 0.2 FTU. This is consistent with well-operated rapid sand filters using adequate pretreatment (Ref. E-3).

The variability of the settled water turbidities, as indicated by the standard deviation, was noticeably larger in some months than others. Specifically, the monthly standard deviation ranged from 0.15 FTU for July, 1986 to 0.87 FTU for July 1984. However, the rapid sand filters did not have a problem achieving filtrate turbidity objectives.

Turbidity removal efficiency for each aspect of plant operation will be discussed in separate sections below.

i) Chemical Type

Presently, alum is used as the primary coagulant and activated silica is used as a coagulant aid. Substitutes for alum have been investigated, however it was found that no performance or economic benefits would result from changing coagulants. Plant staff have investigated the use of ferric chloride and found that it is ineffective for colour removal. The use of polyaluminum chloride (PACl) was investigated in the jar testing phase of this study and found to perform adequately. However it is not as economical as alum.

ii) Flash Mixing

Currently there is no rapid mixing process at Britannia. Rather, the low lift pumps are relied upon for mixing chlorine, alum and raw water. However, the expansion of the Britannia Water Treatment Plant will include mechanical rapid mixing for the alum. Improved performance is

anticipated during the spring break-up season. The degree of improvement will depend largely on the effectiveness of the activated silica at its current point of application. Due to the distance between the alum addition and activated silica application resulting from the plant expansion it may be advisable to move the activated silica addition to a location upstream of the flocculation tanks. This will ensure the optimum lag time between alum and silica addition. One possible location could be the discharge headers from the new rapid mixers.

iii) Flocculation

An evaluation of the spiral flow flocculators is contained in Appendix D. Appendix B contains an evaluation of both chemical dosages and flocculator performance based on jar test results.

The decrease in performance of the flocculation and sedimentation processes during the winter months (see above) is attributed to both colder water temperatures and smaller flow rates. The low flow conditions result in lower Gt values in the flocculation tanks potentially decreasing the size of floc particles. This may only be partially responsible for the lower sludge accumulaton in the settling basin which may also be attributed to the lower raw water turbidities.

One solution could be the removal of one set of flocculation tanks during periods of low plant flow to maintain the velocity gradients necessary for good floc formation. This change could perhaps be investigated during the seasons where flocculation performance is adversely affected by cold water conditions.

iv) Sedimentation

The settling basins may also be partly responsible for decreased performance in terms of high settled water

turbidities during the winter months. In March of 1976, chloride tracer studies were performed on the settling basins at a plant flow of 163 ML/d. It was determined that the tanks had a retention time of 75 min (based on the mode of the residence time distribution). This compares with a calculated hydraulic retention time of 204 min at 163 ML/d and indicates short-circuiting is a problem. The specific causes of the short-circuiting are not clear. However, poor settling hydraulics can result from improperly designed inlet and outlet structures and from density currents resulting from the cold water (Ref. E-3). It is suggested that additional hydraulic studies might reveal the cause or causes of the short-circuiting.

It has been noted that the outlet ports from the flocculation tanks to the sedimentation tanks are too small resulting in high velocity gradients and floc shearing. Visual observations support this finding. Nonetheless, floc reformation at the head end of the sedimentation basin appears also to occur and to a substantial degree to offset the shearing effects.

In order to improve clarifier performance, plant staff have evaluated the effectiveness of plate settlers. Based on these studies it has been determined that the expansion will utilize plate settlers.

v) Filtration

Generally, the filters operate extremely well at Britannia, consistently providing filtered water turbidities below 0.2 FTU over a wide range of settled water turbidities. Filter runs average 48 hours but may get as high as 72 hours in the winter during low flow conditions. It may be possible to extend filter runs by utilizing coarser media. However, given the current performance of the filters and the possiblity of poorer quality water with coarser media, this is not advisable.

Core samples were taken from a filter soon after backwash. The media appeared to be very clean at all filter depths indicating backwashing is adequate.

As discussed in Appendix D, during certain seasons, notably winter, settled water turbidity approaches that of the raw water. This effectively alters Britannia from a conventional plant to a direct filtration plant. Normally, this does not create difficulties since direct filtration is an acceptable water treatment technology. However, the multiple-barrier concept is weakened by the loss of clarification and other factors become important. Concerns about removal of organics and reduction of trihalomethanes (THMs) are important.

Coagulation, flocculation and sedimentation can reduce the organic content of raw water by up to 60% in some plants reducing THM production and improving disinfection by eliminating demand from non-disinfection organic reactions.

vi) Post-Filtration Turbidity

The addition of insoluble impurities during water stabilization with slaked lime has caused significant turbidities in the finished water. This resulted in the moving of the lime feed from the outlet of the clearwell to the point where the filtered water enters the clearwell. The clearwell acts as a sedimentation basin for the insoluble fraction of the lime thereby removing some of the turbidity. As discussed in Section D, other methods of lime addition are being investigated to eliminate this problem.

As already noted, the addition of lime at the head of the clearwell creates pH conditions that are less than optimum for disinfection.

vii) Summary

Overall removal of particulate contaminants at Britannia Water Treatment Plant is excellent due to the reliable performance of the rapid sand filters under a wide range of water temperatures, water quality, and flowrates. The post-filter turbidity is generally less than 0.2 FTU.

However, examination of the particulate removal processes individually suggest that improvements can be made, particularly in the cold water months. The flocculator design parameters, G and Gt, are very low except at peak summer flowrates. Since detention times are well within MOE Guideline values, means of increasing the G values should be considered. The only practical means of changing the velocity heads at the inlets to each flocculation stage is through reduction in cross-sectional area or increased flowrate. Therefore, the addition of hydraulic control devices to the flocculators to achieve these ends may help improve flocculator performance.

A second area of concern is in the settling basins where three conditions exist which adversely affect settling basin performance:

- hydraulic short-circuiting
- high overflow rates
- high weir loading rates

Through RMOC studies, plate settlers have already been identified as being capable of enhancing settling basin performance.

The settling basins in the new plant expansion will be provided with plate settlers. It is recommended the existing settling basins be fitted with plate settlers.

E.2 References

E.1 World Health Organization. Guidelines for Drinking Water Quality, Volume 2. Geneva, Switzerland, 1984.

E.2 Finch, G.R., P.W. Given, and D.W. Smith. A Technology Review of Particle Removal by Water Filtration. Edmonton, Alberta: Alberta Environment, Environmental Protection Services, Standards and Approvals Division, Municipal Engineering Branch. August 1985.

E.3 James M. Montgomery, Consulting Engineers, Inc. Water Treatment Principles and Design. New York, New York: John Wiley & Sons. 1985.

E.4 Hudson, H.E. and E.G. Wagner. Conduct and Use of Jar Tests. Journal of the American Water Works Association. 73(1981):218-223.

E.5 Gore and Storrie Limited. Water Purification Plants Master Plan. Ottawa, Ontario: Regional Municipality of Ottawa-Carleton, 1985.

F. PLANT PERFORMANCE (DISINFECTION)

F.1 Disinfection Practices

Chemical disinfection at Britannia Water Treatment Plant consists of chlorination at two locations:

- o prior to the low-lift pumps
- o after the clearwell, prior to the high lift pumps

(a) Pre-chlorination

Pre-chlorination has been used for a number of reasons (Ref. F-1):

- o control of undesirable microorganisms in the treatment works
- o oxidation of soluble iron and manganese species
- o improved coagulation
- o reduction of colour
- o reduction of taste and odour
- o removal of some pathogenic bacteria
- o oxidation of organic compounds

However, recent concerns regarding the formation of trihalomethanes (THMs) when chlorine reacts with natural humic substances in water has led to the re-evaluation of pre-chlorination practice (Ref. F-2).

In the period 1984 to 1986 pre-chlorination residuals from filters typically ranged between 0.07 to 0.35 mg/L total residual chlorine (TRC). Dosages necessary to achieve the above residuals were typically 1.0 mg/L in the months January to April increasing to between 2.0 to 3.0 mg/L in the warm weather months. The warm weather dosage requirements reflect the increased warm weather chlorine demand of the raw water. Raw water pH was typically 7.1.

As previously noted, pre-chlorination dosage requirements are determined by Quality Control staff utilizing a daily tap sample of filter influent. Residual chlorine measurements are also made at the head of the flocculators and recorded in the operating log.

(b) Post-chlorination

Post-chlorination is provided as the final barrier to the transmission of disease-causing organisms through the plant and to provide a residual to meet the demand in the distribution system. At Britannia pH is adjusted to approximately 8.7 using slaked lime prior to entering the clearwell. Chlorine is added after the clearwell, before the high-lift pumps, to provide a total chlorine residual. The efficiency of chlorine is greatly reduced at the elevated pH and much longer (8-10 times) contact times are required than at pH 7 (Ref. F-1). Over the three year review period, chlorine doses ranged from 0.40 mg/L in November 1985 to 2.11 mg/L in August 1986.

The ranges of total chlorine residual concentrations in the finished water compared to the concentrations requested by Quality Control staff were:

Period	As Requested by Quality Control Staff	Actual Concentration Range
Prior to July 1986	0.9 mg/L	0.9 - 1.0 mg/L
July 1986 on	1.4 mg/L	1.0 - 1.4 mg/L

The proportion of this total chlorine which is free chlorine ranges from 44 to 98%. At the higher chlorine residuals maintained in the summer of 1986, most of the chlorine was free chlorine.

Throughout the study, monthly testing showed positive results for total chlorine residual throughout the distribution system. However, during the summer months and at the extremities of the distribution system, free chlorine levels were reduced to minimum detectable limits.

F.2 Disinfection Efficiency

Reviewing the disinfection data tabulated in Table 6 (Appendix A) reveals no apparent problems with disinfection at the Britannia Water Treatment Plant. No fecal coliforms have been detected in treated water over the period 1983-1986. The bacteriological problem in the summer of 1986 consisted of 3 total coliforms detected in a treated water sample. This resulted in the decision to increase the post-chlorination doses for an increase in the residual in the distribution system.

The World Health Organization (Ref. F-4) recommended 0.2 to 0.5 mg/L of free chlorine residual, maintained for 30 min at a pH of less than 8 as the minimum for ensuring good disinfection.

The Britannia plant is usually successful in obtaining a free chlorine residual of greater than 0.5 mg/L prior to the high-lift pumps. However, there are two concerns with the post-chlorination system:

1. There is no controlled contact time for the chlorinated water before it enters the distribution system.

2. The pH of the finished water is not optimum for efficient chlorine disinfection.

As noted above, free chlorine at a pH of 8.7 takes 8 to 10 times longer to achieve the same degree of disinfection, at the same dose at a pH of 7. Coliform indicator bacteria are readily inactivated using chlorine. However, certain bacteria, viruses, and protozoa require higher dose and/or longer contact times for adequate disinfection.

Consideration should be given to moving the chlorine addition point to before the clearwell and to change the pH adjustment point to after the clearwell. This move would provide two benefits:

- free chlorine at pH 6 (filtrate pH) is a very effective disinfectant

- the clearwell would provide 203 min of controlled contact time at 192 ML/d.

The clearwell would require some modifications to minimize short-circuiting. However, these suggested changes should result in an improved disinfection process.

As well, lime would require degritting to preclude lime deposition in the distribution system. A separate degritter would not be necessary if a lime saturator were employed.

F.3 Chlorinated By-products Formation

Examination of Table 4 (Appendix A) for THM compounds revealed that only chloroform was detected in significant quantities during the first half of 1987 and the last half of 1986. Total THMs were greater than 100 µg/L throughout the last half of 1986 and during May and June of 1987. However, total THMs never exceeded the Ontario Drinking Water Objective of (a one time maximum of) 350 µg/L. If the need to reduce THM levels occurs in Ontario, the Britannia Water Treatment Plant may have to take action.

The formation of chloroform is most probably the result of pre-chlorination of Ottawa River water. The most efficient method of reducing THM formation is through removal of the organic precursors prior to adding chlorine (Ref. F-2). The coagulation/flocculation process has great potential for precursor removal suggesting that the point of chlorine addition should be moved to after the settling basins.

Organic removal would then occur during flocculation/sedimentation. Powdered activated carbon applied in the flocculation/sedimentation stage could also assist in achieving the required organic removal prior to chlorination. Alternatively a non offensive type of pre-disinfectant such as chloramines or chlorine dioxide can be used. Neither of these are particularly attractive as chloramines are slow to react and chlorine dioxide has the potential for causing taste and odour problems. Another alternative is the use of ozone as a pre-oxidant. Ozone treatment has the potential to deal with the THM problem and also bring about significant reduction in colour, TOC, and

hazardous organic chemicals. In 1973-74, the Regional Municipality of Ottawa-Carleton conducted pilot testing with ozone for colour removal.

To reduce the amount of THM formation in the distribution system chloramination could be utilized as a post-disinfectant. It offers the advantages of zero THM formation and greater persistancy as a disinfectant. The decision to use combined chlorine should be carefully considered given that as a disinfectant its reaction rate is very slow and may not offer adequate protection against accidential contamination from cross-connections or main breaks.

F.4 References

F-1 Fair, G.M., J.C. Geyer, and D.A. Okun. Water and Wastewater Engineering, Volume 2. New York, New York: John Wiley & Sons, 1968.

F-2 American Water Works Association. Treatment Techniques for Controlling Trihalomethanes in Drinking Water. Denver, Colorado, 1982.

F-3 United States National Research Council. Drinking Water and Health. Volume 2. Washington, DC: National Academy Press, 1980.

F-4 World Health Organization. Guidelines for Drinking-Water Quality. Volume 1 and 2, Geneva, Switzerland, 1984.

RECOMMENDATIONS

Flow Measurement

The installation of the treated and filtered water venturis deviate somewhat from ideal practice. However flow errors resulting from this deviation are considered to be minimal.

Rapid Mix

At present the low lift pump impellers are used for rapid mixing. The effectiveness of this practice has been questioned, therefore it is recommended that mechanical rapid mixing be installed. It should be noted that the Britannia WTP expansion will incorporate a rapid mix stage.

Flocculators

It has been noted that G values in the winter are lower than those prescribed for flocculation basins. Although retention times appear adequate this does indicate a lack of flexibility for varying plant flows. Nonetheless, the flocculator performance is good. It is recommended that during periods of low flow during the winter months, an evaluation of the removal from service of one set of flocculators be undertaken. This will effectively increase the flow to the remaining flocculators and may result in improved hydraulic control devices may provide a more controlled method for increasing G and Gt values.

Settling

It was found that surface and weir loading rates were high, nonetheless, settled water turbidities are generally good. The worst case is in winter flow conditions where turbidities reach 1-2 FTU. The settling basins in the plant

expansion will contain plate settlers. Since there is some indication of short circuiting, it is recommended that a single basin in the existing plant be isolated and fitted with plate settlers for trial purposes.

Filters

Filter operation is excellent providing filtered water turbidities generally less than 0.2 FTU for a variety of settled water qualities. Core samples taken after a backwash revealed generally clean media.

Disinfection

It was found that pre-chlorination dosages and detention times have provided adequate pre-disinfection. Settled water has consistently shown positive free chlorine residuals. Generally, THM levels in treated water were less than 350 $\mu g/L$, in order to minimize THM formation it is recommended that alternatives be investigated such as the use of alternative oxidants (eg. ozone), activated carbon or the movement of chlorine addition to the beginning of the settling basins be investigated.

Two concerns with post-disinfection are the limited contact time and high pH of the water at the point of chlorine addition.

Therefore it is recommended that the point of lime addition be moved to the clearwell exit (see lime recommendation) and that the clearwell be baffled to minimize short circuiting. It is also recommended that chloramination be evaluated as an alternative post-disinfectant.

Coagulant

Based on jar tests it is recommended that alum continue to

be used as a coagulant. Optimization of alum dosing may be required to low residual aluminum levels in the treated water which has occasionally been higher than 0.1 mg/L. It is understood that the use of a streaming current type monitor for dosage control has been tested at bench scale. However, since alum dosage is based on pH reduction requirements, streaming current was not considered useful.

Coagulant Aid

The point of addition of the coagulant aid may not be optimum for coagulation/flocculation. It is noted that the expansion does address this problem by allowing flexibility in the selection of the additon point relative to alum addition.

Flouride

It was found that the HFS storage area contained no flood wall. It is recommended that a flood wall be installed to prevent the escape of HFS should a tank leak occur.

pH Control

The existing pH control system produces lime fines. This has been partially controlled by movement of the lime addition point of the head of the clearwell thereby allowing the fines to settle out in the clearwell as opposed to the distribution system. However, this does not allow for an optimum disinfection environment due to the high pH in the clearwell. The use of a degritter or lime saturator will allow moving the lime addition point back to the clearwell discharge. Alternatively, NaOH addition will not produce fines.

It should also be noted that although the finished water pH is high it is still mildly aggressive occasionally.

COST IMPLICATIONS OF RECOMMENDATIONS

New Capital	Studies	Operational Changes
Flocculator Hydraulic Controls - slide gate (manual) $5000 installed each	- series out of service (internal)	
Settling	- one tank plate settlers (internal)	
Post-Chlorination - clearwell - baffle walls $60,000	- evaluate/bench test chlorination (internal)	
Pre-Chlorination	- study alternates - oxidants - activated carbon - move pre-disinfection Bench and pilot scale cost - $250-350k	
Coagulant Aid	- identify optimum point of addition (internal)	
Fluoride - floodwall (concrete including lining) $5000		
pH Control	- study most effective method of grit removal - degritter - sodium hydroxide (NaOH) addition - clearwell lime generator	

APPENDIX A
TABLES

LIST OF TABLES FOR APPENDIX A

TABLE 1.0: FLOWS (ML/d) FOR BRITANNIA

Month	R/T	1986			1985			1984			1983		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Jan	R	150.950	70.950	125.218	97.530	51.640	80.165	125.720	40.510	63.459	105.540	23.640	68.064
	T	144.770	65.120	117.280	78.800	48.980	74.037	120.990	37.900	58.419	103.330	22.390	66.446
Feb	R	150.440	78.620	121.480	125.200	68.530	84.340	88.370	54.590	73.934	76.720	35.330	58.201
	T	144.250	71.840	114.337	123.440	63.110	78.782	78.070	50.900	66.225	75.460	34.360	56.408
Mar	R	156.970	80.280	131.323	148.780	99.440	134.465	124.550	75.240	98.451	153.040	61.910	100.187
	T	151.560	75.220	126.236	142.510	92.140	129.005	122.630	71.440	98.853	152.800	58.860	97.420
Apr	R	157.510	105.200	137.789	147.900	109.610	131.273	130.640	47.300	100.055	126.390	46.680	88.652
	T	155.230	99.060	134.499	142.420	104.780	126.766	128.390	47.880	95.239	124.500	44.850	86.120
May	R	183.490	115.940	141.969	144.230	78.880	128.079	142.000	92.500	123.895	122.000	72.800	96.595
	T	178.910	113.520	139.042	141.550	75.180	123.961	141.380	91.370	121.003	120.690	69/150	94.679
Jun	R	180.560	126.540	148.004	146.750	90.210	120.694	179.770	104.500	138.309	160.060	74.230	118.229
	T	174.480	123.890	144.542	142.360	84.600	117.343	177.810	99.570	136.009	155.320	72.990	116.170
Jul	R	185.830	133.820	154.337	177.640	127.340	152.056	175.769	106.640	139.240	167.400	94.000	126.292
	T	183.690	131.680	151.522	171.110	123.130	146.577	170.350	103.670	135.658	165.020	91.150	124.104
Aug	R	158.050	127.840	142.650	192.980	98.920	154.292	174.557	100.122	131.408	144.930	83.270	119.333
	T	152.960	122.210	138.900	182.290	89.350	147.196	171.920	98.190	128.483	143.340	81.530	116.337
Sep	R	168.980	63.110	134.919	152.620	89.210	130.179	142.228	94.873	124.548	192.380	82.450	115.091
	T	166.540	54.320	132.469	146.990	80.990	124.389	140.250	92.750	122.164	186.430	78.020	111.661
Oct	R	166.730	109.520	134.790	152.480	119.850	139.239	147.920	113.290	130.020	139.660	81.130	117.095
	T	164.020	108.090	131.510	140.900	114.290	132.604	145.910	100.600	127.104	137.080	77.810	113.479
Nov	R	143.060	97.900	120.231	165.040	61.160	128.255	193.260	117.600	144.408	169.440	22.380	126.843
	T	139.200	96.100	117.975	143.960	56.690	119.022	188.670	114.890	140.769	164.850	19.590	121.931
Dec	R	122.780	87.910	108.568	150.990	62.300	125.746	146.710	6.179	98.142	135.820	36.340	187.567
	T	121.090	85.410	107.078	144.170	57.650	117.930	142.800	3.788	91.742	132.740	32.180	68.422

R = Raw; T = Treated

TABLE 1.1: PER CAPITA CONSUMPTION FOR REGION OF OTTAWA/CARLETON (L/D/CAPITA)

Consumption	1986	1985	1984	1983
Population (1)	540,000	529,000	515,000	508,200
Maximum Day L/D/Cap.	858	948	860	917
Minimum Day L/D/Cap.	365	386	361	372
Average Day L/D/Cap.	598	592	595	596
Ratio MD/AD	1.43	1.60	1.44	1.54

(1) Central Supply System - Operating Statistics 1983-1986

TABLE 2.0: PARTICULATE REMOVAL SUMMARY FOR BRITANNIA

Month	Parameter		1986			1985			1984			1983		
			Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Jan	Turbidity (FTU)	R	3.0	1.0	1.4	3.8	1.6	2.2	3.0	1.2	1.6	3.8	1.9	2.5
		T	0.55	0.26	0.33	0.38	0.14	0.27	0.48	0.30	0.40	0.46	0.22	0.34
	Colour (TCU)	R	46	37	41	49	41	44	49	42	45	49	41	45
		T	4	3	4	5	3	4	5	4	4	4	3	4
	Alum (mg/L)		35	34	35	31	29	30	38	33	35	39	32	34
	Sodium Silicate (mg/L)		1.75	1.75	1.75	1.26	1.05	1.0	2.80	0.95	1.73	1.00	1.00	1.00
	Lime (mg/L)		17	12	15	14	11	13	18	12	15	17	12	15
	pH	R	7.3	6.9	7.1	7.3	6.9	7.1	7.4	7.0	7.2	7.3	7.0	7.1
		T	8.8	8.5	8.7	8.7	8.4	8.6	9.1	8.6	8.9	8.9	8.5	8.7
	Temperature (°C)		1.0	0.4	0.7	1.0	0.3	0.4	0.7	0.0	0.4	0.3	0.0	0.1
Feb	Turbidity (FTU)	R	3.3	2.0	2.4	3.0	2.1	2.5	3.7	1.4	2.4	3.3	2.1	2.4
		T	0.71	0.27	0.35	0.53	0.22	0.28	0.48	0.32	0.42	0.40	0.25	0.31
	Colour (TCU)	R	50	34	41	46	36	43	48	36	42	49	40	44
		T	4	3	3	4	3	4	4	4	4	4	4	4
	Alum (mg/L)		35	33	34	30	29	30	37	32	34	36	30	32
	Sodium Silicate (mg/L)		2.05	1.75	1.79	1.07	1.05	1.07	2.68	1.47	1.96	1.00	1.00	1.00
	Lime (mg/L)		18	10	12	14	12	13	19	12	16	14	11	12
	pH	R	7.2	6.9	7.0	7.2	6.9	7.1	7.2	7.0	7.1	7.2	7.0	7.1
		T	8.7	8.6	8.6	8.7	8.5	8.7	9.1	8.5	8.9	8.9	8.6	8.8
	Temperature (°C)		1.0	0.3	0.5	0.7	0.4	0.5	1.5	0.4	0.5	1.0	0.0	0.3
Mar	Turbidity (FTU)	R	5.4	2.5	3.0	5.3	2.6	3.8	3.5	2.5	3.0	14.0	2.6	5.1
		T	1.20	0.27	0.40	1.1	0.25	0.44	0.62	0.26	0.44	0.43	0.13	0.33
	Colour (TCU)	R	46	33	40	48	34	43	47	40	43	49	39	44
		T	4	3	4	4	3	3	4	4	4	5	4	4
	Alum (mg/L)		41	33	36	37	29	34	39	36	37	34	28	31
	Sodium Silicate (mg/L)		2.40	1.75	1.97	1.55	1.05	1.27	2.64	1.52	1.84	2.00	1.00	1.39
	Lime (mg/L)		17	14	15	16	12	14	18	12	15	16	12	14
	pH	R	7.2	6.8	7.0	7.3	7.0	7.2	7.1	6.9	7.0	7.2	6.9	7.1
		T	8.8	8.6	8.7	8.7	8.5	8.6	9.1	8.7	8.9	8.9	8.7	8.8
	Temperature (°C)		1.1	0.3	0.5	1.2	0.5	0.7	1.5	0.3	0.5	0.5	0.0	0.3

R = Raw; T= Treated

TABLE 2.0: (cont'd): PARTICULATE REMOVAL SUMMARY FOR BRITANNIA

Month	Parameter		1986			1985			1984			1983		
			Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Apr	Turbidity (FTU)	R	10.0	1.9	3.7	15.0	5.0	8.9	25.0	3.0	8.4	11.0	3.1	5.7
		T	1.50	0.25	0.46	1.4	0.30	0.55	2.3	0.19	0.56	0.48	0.30	0.40
	Colour (TCU)	R	45	36	39	50	36	44	61	43	48	45	35	42
		T	5	2	3	4	3	3	4	3	4	4	4	4
	Alum (mg/L)		43	33	38	41	35	39	43	39	42	44	33	39
	Sodium Silicate (mg/L)		2.40	1.12	1.90	2.00	1.05	1.46	1.61	1.53	1.54	1.62	0.95	1.27
	Lime (mg/L)		17	12	13	16	13	14	22	16	18	18	11	15
	pH	R	7.3	7.0	7.2	7.5	7.2	7.4	7.4	7.0	7.2	7.4	7.1	7.2
		T	8.7	8.6	8.7	8.8	8.6	8.7	9.1	8.6	8.9	8.9	8.7	8.8
	Temperature (°C)		10.0	0.9	5.0	7.3	0.8	3.3	10.0	1.0	4.3	6.4	0.5	2.5
May	Turbidity (FTU)	R	6.1	1.5	2.4	4.7	2.2	3.0	5.8	2.8	3.6	9.0	2.7	4.3
		T	0.68	0.12	0.33	0.40	0.23	0.32	2.2	0.15	0.52	0.42	0.25	0.32
	Colour (TCU)	R	50	36	40	48	35	41	50	32	41	49	37	41
		T	5	3	4	4	3	3	4	3	3	5	4	4
	Alum (mg/L)		33	24	27	38	24	30	42	36	39	37	31	35
	Sodium Silicate (mg/L)		1.60	0.77	1.12	1.51	0.92	1.10	1.53	0.53	0.92	1.20	0.54	1.01
	Lime (mg/L)		16	11	12	14	11	12	17	10	14	15	12	13
	pH	R	7.3	7.1	7.2	7.3	7.0	7.2	7.5	7.2	7.4	7.4	7.2	7.3
		T	8.7	8.6	8.7	8.9	8.6	8.7	9.0	8.5	8.7	8.9	8.7	8.8
	Temperature (°C)		17.4	9.5	13.0	15.1	7.7	11.2	14.5	9.0	11.7	12.0	7.8	9.8
Jun	Turbidity (FTU)	R	3.5	1.2	1.5	3.4	1.8	2.4	6.4	1.7	4.4	4.1	2.7	3.2
		T	0.55	0.15	0.25	0.44	0.22	0.25	0.35	0.12	0.20	0.34	0.19	0.25
	Colour (TCU)	R	41	33	37	48	36	42	46	36	42	49	35	44
		T	4	3	3	4	3	3	5	3	4	5	4	4
	Alum (mg/L)		33	29	31	29	23	27	34	22	26	30	25	26
	Sodium Silicate (mg/L)		2.48	1.60	2.23	1.04	0.57	0.92	1.03	0.19	0.61	0.58	0.24	0.53
	Lime (mg/L)		15	12	14	11	10	10	15	9	12	14	10	11
	pH	R	7.4	7.2	7.3	7.4	7.0	7.2	7.4	7.1	7.2	7.3	7.0	7.1
		T	8.8	8.6	8.6	8.8	8.6	8.7	8.8	8.5	8.7	8.9	8.7	8.8
	Temperature (°C)		21.2	15.9	17.9	18.7	15.0	15.9	20.5	13.5	18.1	20.8	12.0	16.6

R = Raw; T= Treated

TABLE 2.0 (cont'd): PARTICULATE REMOVAL SUMMARY FOR BRITANNIA

Month	Parameter		1986			1985			1984			1983		
			Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
Jul	Turbidity (FTU)	R	1.6	0.8	1.2	1.7	0.8	1.2	7.0	2.3	4.1	3.5	1.7	2.6
		T	1.50	0.29	0.66	0.44	0.21	0.29	0.26	0.12	0.19	0.32	0.15	0.25
	Colour (TCU)	R	39	30	33	39	30	33	44	35	38	49	30	37
		T	4	1	3	3	2	3	5	3	4	6	3	4
	Alum (mg/L)		31	29	30	28	24	27	26	23	24	28	25	25
	Sodium Silicate (mg/L)		1.00	0.50	0.96	1.00	0.06	0.53	1.05	0.20	0.68	0.52	0.23	0.43
	Lime (mg/L)		15	11	14	12	10	11	14	10	12	14	10	11
	pH	R	7.5	7.1	7.3	7.4	7.2	7.3	7.4	7.0	7.2	7.5	7.1	7.3
		T	8.8	8.6	8.7	8.8	8.6	8.7	8.8	8.4	8.7	8.9	8.7	8.8
	Temperature(°C)		23.7	19.2	21.4	23.0	19.0	21.7	22.5	20.1	21.5	24.2	20.5	22.4
Aug	Turbidity (FTU)	R	2.4	0.8	1.09	1.2	0.7	0.9	2.6	1.7	2.1	2.8	1.3	1.7
		T	2.90	0.13	0.94	0.30	0.15	0.20	0.23	0.14	0.17	0.38	0.16	0.25
	Colour (TCU)	R	36	28	31	41	28	36	41	35	38	35	27	32
		T	4	2	3	4	3	3	4	3	4	4	4	4
	Alum (mg/L)		33	30	32	25	21	22	27	24	25	27	25	26
	Sodium Silicate (mg/L)		1.00	0.50	0.61	0.68	0.11	0.42	0.55	0.11	0.39	0.83	0.15	0.43
	Lime (mg/L)		17	12	14	11	10	10	16	10	13	14	11	12
	pH	R	7.6	7.3	7.4	7.4	7.2	7.3	7.5	7.0	7.3	7.4	7.2	7.3
		T	8.8	8.6	8.7	8.8	8.6	8.7	8.7	8.6	8.6	8.9	8.7	8.8
	Temperature(°C)		23.1	18.6	18.0	23.9	20.1	21.8	24.2	21.5	22.2	25.0	21.5	23.1
Sep	Turbidity (FTU)	R	3.9	0.8	1.5	1.3	0.6	0.8	5.4	1.6	2.1	2.8	1.3	1.8
		T	6.0	0.24	1.9	0.31	0.16	0.19	0.22	0.14	0.17	0.37	0.22	0.27
	Colour (TCU)	R	33	28	31	40	32	37	42	35	40	40	27	33
		T	4	2	3	4	2	3	4	3	3	4	3	4
	Alum (mg/L)		38	29	33	26	24	25	27	25	27	32	27	29
	Sodium Silicate (mg/L)		0.55	0.50	0.52	1.90	1.72	1.82	0.51	0.11	0.36	0.56	0.15	0.41
	Lime (mg/L)		18	12	15	12	9	11	15	13	14	16	12	14
	pH	R	7.6	7.2	7.5	7.4	7.2	7.3	7.5	7.0	7.3	7.4	7.0	7.3
		T	8.8	8.5	8.6	8.9	8.5	8.7	8.9	8.6	8.7	8.9	8.7	8.8
	Temperature(°C)		19.4	15.4	16.9	20.1	17.4	18.2	21.9	15.8	18.3	23.9	17.0	20.6

R = Raw; T= Treated

TABLE 2.0 (cont'd): PARTICULATE REMOVAL SUMMARY FOR BRITANNIA

Month	Parameter		1986 Max.	1986 Min.	1986 Avg.	1985 Max.	1985 Min.	1985 Avg.	1984 Max.	1984 Min.	1984 Avg.	1983 Max.	1983 Min.	1983 Avg.
Oct	Turbidity (FTU)	R	3.6	1.2	1.7	2.5	1.0	1.2	3.8	1.3	1.8	6.8	1.5	2.3
		T	6.1	0.31	2.8	0.34	0.18	0.23	0.25	0.11	0.18	0.47	0.17	0.29
	Colour (TCU)	R	42	29	37	43	31	36	44	37	41	41	30	35
		T	4	3	4	4	2	3	4	3	3	4	3	3
	Alum (mg/L)		41	37	39	36	27	28	28	26	27	31	29	31
	Sodium Silicate (mg/L)		1.05	0.55	0.62	0.55	0.14	0.46	0.51	0.24	0.42	0.88	0.16	0.34
	Lime (mg/L)		21	16	18	15	11	13	15	12	13	15	13	14
	pH	R	7.6	7.2	7.5	7.5	7.1	7.3	7.5	7.2	7.3	7.5	7.1	7.4
		T	8.7	8.0	8.3	8.8	8.5	8.7	9.0	8.4	8.7	9.0	8.7	8.8
	Temperature (°C)		16.2	9.4	12.3	17.5	10.1	13.5	15.4	11.5	13.3	18.2	8.6	13.2
Nov	Turbidity (FTU)	R	2.3	1.3	1.7	1.6	1.1	1.4	6.9	1.5	2.5	5.4	1.5	2.1
		T	2.10	0.22	0.57	0.39	0.16	0.23	0.32	0.13	0.17	0.56	0.25	0.37
	Colour (TCU)	R	47	38	41	42	32	35	50	40	44	43	35	38
		T	4	2	3	3	2	3	4	3	3	4	3	3
	Alum (mg/L)		40	30	35	32	28	30	30	26	28	32	31	32
	Sodium Silicate (mg/L)		1.07	1.05	1.05	1.00	0.26	0.81	1.05	0.36	0.69	1.09	0.24	0.79
	Lime (mg/L)		18	12	15	16	12	14	12	11	11	16	13	14
	pH	R	7.5	7.1	7.3	7.5	7.1	7.3	7.4	7.0	7.2	7.5	7.1	7.3
		T	8.6	7.8	8.3	8.7	8.6	8.7	8.8	8.6	8.8	8.9	8.7	8.8
	Temperature (°C)		9.4	1.8	5.3	10.1	2.5	6.3	11.0	3.4	6.6	9.0	2.5	5.6
Dec	Turbidity (FTU)	R	2.1	1.6	1.8	8.2	1.0	1.6	2.3	1.4	2.0	6.7	1.2	2.2
		T	1.80	0.25	0.48	0.37	0.18	0.26	0.32	0.17	0.24	0.52	0.24	0.39
	Colour (TCU)	R	46	33	40	44	33	37	50	41	46	48	38	43
		T	4	2	3	3	2	3	5	3	4	5	3	4
	Alum (mg/L)		38	33	34	34	25	33	31	29	30	37	31	36
	Sodium Silicate (mg/L)		1.07	1.07	1.07	1.80	1.00	1.52	1.32	0.95	1.10	1.56	0.32	1.17
	Lime (mg/L)		15	12	13	16	13	14	13	10	12	16	10	14
	pH	R	7.3	7.0	7.2	7.4	7.0	7.2	7.3	7.1	7.2	7.6	7.2	7.3
		T	8.7	8.1	8.5	8.8	8.6	8.7	9.4	8.5	8.7	9.2	8.7	8.9
	Temperature (°C)		1.7	0.7	1.0	2.4	0.6	0.9	4.1	0.3	2.0	2.5	0.4	1.0

R = Raw; T= Treated

TABLE 2.1: PARTICULATE REMOVAL PROFILE (1986) JANUARY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	1.2	1.8	0.12	0.32	40	3	34	1.75	13	7.1	8.7	0.7
2	1.6	1.6	0.16	0.33	44	3	35	1.75	12	7.3	8.8	1.0
3	1.1	1.6	0.15	0.31	46	3	35	1.75	13	7.3	8.8	0.8
4	1.1	1.5	0.16	0.35	45	3	34	1.75	15	7.1	8.7	0.7
5	1.0	1.6	0.14	0.31	45	3	34	1.75	15	7.1	8.6	0.6
6	1.3	1.7	0.13	0.38	45	4	34	1.75	14	7,2	8.5	0.5
7	1.2	1.2	0.27	0.34	43	4	34	1.75	14	7.0	8.6	0.7
8	1.3	1.1	0.12	0.58	44	4	35	1.75	17	6.9	8.6	0.7
9	1.2	1.2	0.18	0.38	49	4	35	1.75	15	7.1	8.6	0.7
10	1.1	1.7	0.11	0.39	50	4	35	1.75	14	7.1	8.6	1.0
11	1.3	1.7	0.21	0.38	LA	4	35	1.75	15	7.1	8.7	1.0
12	1.3	1.7	0.18	0.36	45	4	35	1.75	14	7.2	8.6	1.1
13	1.2	1.6	0.22	0.32	41	4	35	1.75	14	7.1	8.7	0.7
14	1.1	1.5	0.16	0.34	43	4	35	1.75	14	7.2	8.7	0.8
15	1.8	1.2	0.15	0.40	42	4	34	1.75	13	7.2	8.6	0.8
16	1.2	1.1	0.12	0.27	40	4	35	1.75	15	7.1	8.7	0.7
17	1.2	1.4	0.11	0.37	38	4	34	1.75	14	7.1	8.6	0.8
18	1.2	1.4	0.14	0.34	37	4	35	1.75	13	7.0	8.6	0.9
19	1.2	1.4	0.10	0.38	37	4	35	1.75	15	7.0	8.7	1.0
20	1.1	1.5	0.14	0.35	37	3	35	1.75	15	7.1	8.7	0.9
21	1.4	1.5	0.12	0.30	37	3	35	1.75	15	7.0	8.6	0.8
22	1.4	2.0	0.17	0.30	37	4	35	1.75	14	6.9	8.7	0.6
23	1.3	1.5	0.11	0.30	37	4	34	1.75	15	7.0	8.7	0.5
24	1.4	1.4	0.11	0.26	37	4	34	1.75	16	7.0	8.6	0.8
25	1.5	1.0	0.10	0.28	37	4	34	1.75	15	7.1	8.6	0.6
26	1.5	1.2	0.10	0.30	37	4	35	1.75	14	7.0	8.7	0.6
27	1.8	1.4	0.12	0.27	37	4	34	1.75	15	7.1	8.6	0.5
28	1.7	1.1	0.11	0.26	43	4	34	1.75	16	7.0	8.7	0.4
29	1.8	1.2	0.12	0.30	40	3	34	1.75	15	7.1	8.6	0.6
30	1.7	1.4	0.11	0.26	40	4	35	1.75	16	7.1	8.7	0.6
31	3.0	1.6	0.12	0.26	46	4	34	1.75	16	6.9	8.6	0.8

LA-Lab Accident

TABLE 2.1 (cont'd): PARTICULATE REMOVAL PROFILE (1986) MAY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	1.9	1.4	0.12	0.27	45	3	32	1.60	13	7.1	8.7	11.1
2	4.1	1.2	0.34	0.37	50	3	28	1.45	13	7.2	8.6	10.5
3	2.6	1.2	0.14	0.36	43	3	28	1.45	11	7.1	8.7	10.0
4	2.6	1.0	0.15	0.36	NA	3	28	1.45	11	7.2	8.6	9.5
5	2.0	1.0	0.21	0.36	50	4	29	1.45	11	7.2	8.6	9.6
6	1.9	1.3	0.19	0.34	NA	4	29	1.58	12	7.2	8.7	9.8
7	2.0	1.2	0.17	0.33	NA	4	28	1.21	12	7.1	8.7	9.6
8	2.1	1.6	0.18	0.42	42	5	28	0.77	12	7.1	8.7	10.4
9	2.2	1.3	0.15	0.32	NA	3	27	0.95	12	7.2	8.7	10.7
10	2.1	1.1	0.23	0.34	36	4	27	0.95	12	7.1	8.7	11.9
11	2.0	1.3	0.19	0.31	36	3	26	0.95	12	7.2	8.7	11.9
12	2.0	1.1	0.26	0.30	40	3	26	0.95	12	7.2	8.6	11.9
13	1.9	1.1	0.15	0.30	39	3	25	0.95	11	7.1	8.7	12.2
14	1.6	1.2	0.14	0.30	39	3	24	0.95	11	7.2	8.7	12.4
15	1.5	1.1	0.15	0.29	39	3	24	0.95	11	7.1	8.7	12.8
16	1.6	1.0	0.25	0.30	36	8	24	0.95	11	7.1	8.7	13.0
17	1.7	1.1	0.18	0.32	36	8	24	0.95	11	7.1	8.7	13.5
18	1.5	1.0	0.20	0.30	36	8	24	0.95	12	7.1	8.7	14.2
19	1.5	0.7	0.17	0.12	36	8	24	0.95	11	7.1	8.7	14.0
20	1.5	1.0	0.12	0.13	36	8	24	0.95	12	7.1	8.7	13.7
21	2.0	1.4	0.17	0.25	36	8	24	0.95	12	7.1	8.7	14.0
22	1.6	1.5	0.10	0.23	36	8	24	0.95	12	7.1	8.7	14.0
23	5.9	1.8	0.20	0.22	42	8	24	0.95	12	7.1	8.6	13.7
24	6.1	4.5	0.45	0.25	42	5	27	1.05	13	7.1	8.7	14.5
25	3.7	1.2	0.12	0.32	42	4	30	1.25	14	7.1	8.6	15.0
26	3.2	1.3	0.06	0.42	42	4	30	1.20	14	7.1	8.7	14.7
27	3.4	1.7	0.14	0.34	43	5	31	1.25	14	7.1	8.7	14.9
28	2.9	1.3	0.16	0.68	36	4	33	1.25	15	7.4	8.7	16.8
29	2.3	1.9	0.06	0.39	38	4	33	1.20	16	7.3	8.7	17.4
30	1.8	0.8	0.06	0.50	38	4	33	1.25	15	7.3	8.6	17.3
31	1.6	0.7	0.06	0.62	38	4	32	1.25	14	7.3	8.6	17.0

NA - not available

TABLE 2.1 (cont'd): PARTICULATE REMOVAL PROFILE (1986) JULY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	1.3	1.1	0.09	0.30	37	4	29	1.00	12	7.3	8.7	20.6
2	1.2	0.9	0.11	0.29	36	3	29	0.94	14	7.3	8.8	19.4
3	1.3	0.7	0.12	0.38	36	3	29	0.91	11	7.3	8.8	19.2
4	1.4	1.1	0.14	0.30	33	3	29	1.00	13	7.3	8.6	19.4
5	1.3	0.6	0.10	0.38	35	4	29	1.00	15	7.2	8.6	19.8
6	1.2	0.6	0.12	0.30	35	4	30	1.00	15	7.2	8.6	19.8
7	1.3	0.9	0.18	0.41	35	3	29	0.66	14	7.3	8.7	20.7
8	1.5	1.0	0.11	0.55	33	2	29	0.50	13	7.2	8.5	21.0
9	1.7	0.7	0.16	0.85	39	4	29	0.71	14	7.2	8.6	21.5
10	1.3	0.9	0.12	0.65	37	4	30	1.00	13	7.5	8.7	21.5
11	1.6	0.7	0.13	0.81	37	3	29	1.00	13	7.5	8.6	20.5
12	1.5	0.7	0.10	0.47	33	3	30	1.00	13	7.5	8.5	20.4
13	1.1	0.5	0.11	0.61	33	3	30	1.00	13	7.4	8.6	20.3
14	1.2	0.81	0.15	0.70	33	3	30	1.00	15	7.3	8.6	20.1
15	1.1	0.75	0.14	0.75	35	1	30	1.00	15	7.5	8.6	20.1
16	1.2	0.85	0.25	0.91	36	1	30	1.00	14	7.3	8.7	20.7
17	1.1	0.67	0.12	0.56	34	2	31	1.00	14	7.4	8.7	20.1
18	1.1	0.75	0.15	0.52	32	2	31	1.00	14	7.4	8.7	21.1
19	1.0	0.68	0.10	0.35	32	3	31	1.00	13	7.4	8.7	22.0
20	1.0	0.8	0.17	0.73	32	4	31	1.00	14	7.3	8.7	22.3
21	1.0	0.7	0.15	0.75	30	4	31	1.00	14	7.4	8.7	22.2
22	1.0	0.69	0.14	0.60	32	3	31	1.00	13	7.3	8.6	22.1
23	0.93	0.70	0.12	0.74	31	4	31	1.00	14	7.4	8.7	22.5
24	0.93	0.75	0.20	0.72	32	4	31	1.00	14	7.3	8.7	22.5
25	1.0	0.83	0.19	0.87	30	4	31	1.00	14	7.4	8.8	22.7
26	1.0	0.82	0.10	0.82	30	4	31	1.00	14	7.3	8.7	23.6
27	0.8	1.57	0.10	0.64	30	4	31	1.00	14	7.4	8.8	23.5
28	1.0	0.65	0.15	0.75	30	3	31	1.00	14	7.4	8.6	23.7
29	0.95	0.72	0.13	1.00	30	1	31	1.00	14	7.3	8.6	23.5
30	1.50	0.52	0.15	1.2	30	3	31	1.00	14	7.1	8.6	23.5
31	1.1	0.60	0.16	1.5	30	3	31	1.00	14	7.3	8.7	23.5

TABLE 2.1 (cont'd): PARTICULATE REMOVAL PROFILE (1986) OCTOBER/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	1.5	NA	0.09	3.7	29	4	38	0.55	18	7.6	8.6	16.0
2	1.2	NA	0.05	4.5	33	4	38	0.55	19	7.5	8.6	16.1
3	1.3	0.7	0.06	5.5	33	4	37	0.55	19	7.4	8.6	NA
4	1.6	0.9	0.07	4.6	32	4	39	0.55	20	7.4	8.6	16.2
5	1.5	0.8	0.26	6.1	31	4	38	0.55	20	7.4	8.6	15.2
6	1.8	1.2	0.42	3.4	33	3	37	0.55	18	7.6	8.6	15.1
7	3.2	1.1	0.08	5.8	NA	3	39	0.55	20	7.6	8.7	14.4
8	3.6	2.1	0.07	1.7	NA	3	38	0.55	18	7.6	8.6	14.1
9	2.4	1.0	0.05	3.5	33	4	39	0.55	18	7.6	8.6	14.1
10	2.2	0.7	0.06	2.8	33	3	38	0.55	18	7.4	8.2	12.3
11	2.2	1.0	0.05	1.5	40	3	38	0.55	16	7.5	8.0	12.0
12	2.1	0.8	0.10	2.5	39	3	38	0.55	17	7.5	8.0	12.1
13	1.9	0.8	0.05	3.9	41	3	38	0.55	18	7.5	8.1	12.5
14	1.6	0.8	0.35	4.2	39	3	39	0.57	17	7.5	8.2	12.2
15	1.7	1.1	0.16	2.0	36	4	38	0.68	16	7.5	8.2	11.6
16	1.5	1.1	0.06	1.1	42	4	39	0.57	16	7.5	8.2	11.8
17	1.5	1.4	0.06	1.2	38	4	41	0.57	15	7.4	8.2	11.6
18	1.5	1.2	0.05	1.7	39	4	41	0.57	15	7.5	8.1	11.4
19	1.4	1.2	0.05	4.2	38	4	40	0.57	17	7.4	8.1	11.4
20	1.4	1.3	0.08	2.6	38	3	41	0.57	18	7.5	8.1	11.4
21	1.4	1.1	0.07	4.5	39	3	40	0.57	18	7.5	8.0	11.4
22	1.5	1.0	0.12	3.6	39	3	40	0.57	17	7.2	8.2	12.0
23	1.2	0.7	0.08	4.0	39	3	40	0.57	20	7.5	8.1	11.7
24	1.6	1.0	0.04	3.1	39	3	40	0.57	20	7.6	8.3	10.4
25	1.4	1.2	0.06	0.82	40	4	39	0.57	17	7.5	8.2	10.6
26	1.4	1.4	0.08	0.65	40	4	40	0.57	17	7.4	8.5	10.8
27	1.3	0.9	0.10	0.53	39	4	39	0.57	18	7.3	8.3	10.9
28	1.3	1.5	0.31	0.52	36	4	39	0.89	17	7.3	8.2	10.6
29	1.3	1.1	0.09	0.31	44	3	39	1.05	17	7.3	8.5	10.4
30	2.4	3.5	0.15	1.60	42	4	39	1.05	20	7.4	8.2	9.9
31	1.5	2.0	0.13	1.90	40	3	39	1.05	21	7.4	8.1	9.4

NA - not available

TABLE 2.2: PARTICULATE REMOVAL PROFILE (1985) JANUARY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	1.8	1.3	0.06	0.21	44	4	29	1.05	13	7.2	8.6	1.0
2	1.9	1.1	0.15	0.24	44	4	30	1.05	12	7.2	8.7	0.4
3	2.0	1.1	0.14	0.29	45	4	30	1.05	12	7.0	8.7	0.4
4	2.0	1.2	0.32	0.14	45	4	30	1.05	12	7.2	8.6	0.4
5	2.0	1.3	0.05	0.18	44	4	30	1.05	12	7.2	8.6	0.8
6	2.0	1.3	0.07	0.19	44	4	30	1.05	12	7.2	8.7	0.7
7	2.1	1.5	0.10	0.22	45	4	30	1.05	12	7.3	8.7	0.6
8	2.0	1.1	0.15	0.22	47	4	30	1.26	12	7.2	8.7	0.4
9	3.8	1.2	0.26	0.21	45	5	30	1.05	12	7.2	8.5	0.4
10	2.1	1.2	0.08	0.19	45	4	31	1.05	12	7.3	8.5	1.0
11	2.6	1.5	0.15	0.26	44	4	30	1.05	12	7.2	8.4	0.3
12	1.9	1.5	0.06	0.20	-	4	29	1.05	12	7.2	8.7	0.3
13	1.9	1.5	0.06	0.20	45	4	29	1.05	12	7.1	8.5	0.3
14	1.8	1.4	0.12	0.30	45	4	30	1.05	13	7.2	8.6	0.3
15	2.4	1.2	0.25	0.38	46	4	30	1.05	13	7.2	8.7	0.4
16	2.1	1.4	0.08	0.26	42	4	30	1.05	12	7.1	8.5	0.3
17	2.1	1.3	0.11	0.33	42	4	30	1.05	12	7.2	8.6	0.3
18	2.2	1.2	0.22	0.36	42	4	30	1.05	13	7.1	8.6	0.3
19	1.8	1.3	0.10	0.20	43	4	30	1.05	12	7.1	8.5	0.3
20	2.1	1.2	0.08	0.26	43	4	30	1.05	13	7.0	8.5	0.3
21	2.2	1.2	0.12	0.28	42	4	29	1.05	12	7.0	8.5	0.3
22	2.1	1.4	0.23	0.30	49	3	30	1.05	14	7.2	8.5	0.3
23	2.4	1.1	0.22	0.32	46	4	30	1.05	14	7.1	8.5	0.3
24	2.4	1.3	0.13	0.38	42	4	30	1.05	13	7.1	8.5	0.4
25	2.3	1.7	0.20	0.24	42	3	30	1.05	11	7.0	8.5	0.4
26	1.9	1.5	0.07	0.27	44	4	30	1.05	13	7.1	8.7	0.4
27	2.0	1.5	0.11	0.33	43	4	29	1.05	13	7.0	8.7	0.6
28	2.2	1.3	0.27	0.28	45	3	30	1.05	13	7.1	8.7	0.4
29	2.1	1.7	0.13	0.38	41	3	30	1.05	13	6.9	8.6	0.4
30	2.2	1.5	0.12	0.36	41	3	30	1.05	13	6.9	8.6	0.4
31	2.3	1.4	0.26	0.36	43	4	29	1.05	13	7.1	8.7	0.4

TABLE 2.2 (cont'd): PARTICULATE REMOVAL PROFILE (1985) MAY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	4.6	2.3	0.18	0.40	48	4	38	1.51	13	7.2	8.7	7.7
2	4.7	1.9	0.13	0.39	48	3	32	1.25	13	7.1	8.7	8.1
3	4.6	1.6	0.13	0.33	46	4	34	1.25	14	7.2	8.7	8.0
4	3.8	1.1	0.05	0.38	NS	3	34	1.25	13	7.0	8.7	8.7
5	4.0	1.3	0.06	0.33	NS	4	34	1.25	13	7.2	8.7	8.8
6	3.6	1.3	0.17	0.35	46	4	35	1.25	13	7.2	8.7	8.3
7	3.2	1.3	0.20	0.35	48	3	33	1.25	13	7.2	8.7	8.7
8	4.1	1.3	0.26	0.36	46	3	32	1.25	12	7.2	8.7	8.4
9	3.0	1.1	0.15	0.40	39	3	32	1.25	12	7.2	8.7	8.7
10	3.3	1.5	0.20	0.30	41	3	33	1.25	13	7.2	8.7	8.9
11	2.9	1.6	0.16	0.35	36	3	33	1.25	12	7.2	8.7	8.9
12	2.9	1.3	0.20	0.36	35	3	32	1.25	13	7.2	8.7	8.9
13	2.6	1.5	0.14	0.35	35	3	31	1.25	13	7.2	8.7	10.4
14	3.3	1.2	0.12	0.33	38	3	30	1.25	12	7.2	8.7	10.3
15	2.8	1.0	0.17	0.30	41	3	30	1.06	13	7.1	8.7	10.5
16	3.0	1.2	0.26	0.35	44	3	30	1.00	12	7.2	8.7	12.0
17	2.3	1.3	0.16	0.31	44	3	30	1.05	12	7.0	8.7	11.6
18	2.3	1.1	0.11	0.26	39	4	30	1.05	12	7.2	8.6	11.9
19	2.2	1.2	0.11	0.23	39	4	29	1.05	12	7.0	8.6	12.0
20	2.4	1.1	0.18	0.34	39	4	28	1.05	12	7.0	8.9	12.4
21	2.9	1.1	0.14	0.30	43	3	26	1.05	12	7.2	8.8	12.4
22	2.5	1.5	0.15	0.27	41	3	25	1.05	11	7.1	8.7	12.6
23	2.6	0.9	0.14	0.36	42	3	26	0.68	11	7.3	8.7	13.7
24	2.8	1.3	0.13	0.30	39	3	27	1.05	11	7.2	8.7	14.0
25	2.3	1.0	0.16	0.24	37	3	26	0.95	11	7.2	8.7	14.1
26	2.4	1.2	0.12	0.28	35	3	26	1.05	11	7.1	8.7	14.8
27	2.3	1.1	0.15	0.30	35	3	25	0.47	11	7.2	8.7	14.5
28	2.2	1.7	0.25	0.28	45	3	24	0.46	12	7.1	8.7	14.4
29	2.2	1.2	0.15	0.25	41	3	24	1.05	11	7.2	8.7	14.6
30	2.3	2.1	0.15	0.26	39	3	24	1.05	11	7.1	8.7	15.1
31	2.3	1.8	0.14	0.36	48	4	24	0.92	11	7.2	8.7	14.5

NS - no sample

TABLE 2.2 (cont'd): PARTICULATE REMOVAL PROFILE (1985) JULY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	1.7	1.5	0.13	0.24	38	0.24	28	1.00	11	7.3	8.7	19.0
2	1.6	1.5	0.13	0.26	39	0.26	28	1.00	11	7.3	8.6	19.1
3	1.6	1.2	0.20	0.27	35	0.27	28	1.00	10	7.4	8.6	19.5
4	1.6	0.7	0.16	0.25	33	0.25	28	0.96	11	7.4	8.7	21.2
5	1.6	0.8	0.13	0.23	35	0.23	28	0.76	11	7.4	8.7	20.7
6	1.3	1.0	0.20	0.25	39	0.25	27	0.50	11	7.4	8.6	21.0
7	1.3	0.6	0.17	0.31	35	0.31	26	0.50	11	7.3	8.7	21.5
8	1.3	0.7	0.16	0.31	35	0.31	28	0.87	11	7.3	8.6	20.8
9	1.1	0.6	0.13	0.25	33	0.25	28	1.00	11	7.3	8.7	22.0
10	1.0	0.8	0.21	0.28	32	0.28	28	0.75	11	7.3	8.6	22.3
11	1.1	0.8	0.17	0.40	38	0.40	28	0.46	11	7.4	8.6	21.8
12	1.4	0.6	0.25	0.35	31	0.35	28	0.46	11	7.3	8.6	22.0
13	1.2	0.8	0.18	0.38	32	0.38	27	0.50	11	7.3	8.7	22.0
14	1.1	0.9	0.21	0.38	32	0.38	27	0.45	11	7.3	8.7	22.2
15	1.2	0.7	0.21	0.30	32	0.30	27	0.50	12	7.3	8.7	22.2
16	1.2	0.7	0.28	0.44	32	0.44	27	0.50	12	7.3	8.6	21.9
17	1.2	1.0	0.19	0.28	30	0.28	28	0.48	12	7.3	8.6	20.0
18	1.1	0.7	0.19	0.27	31	0.27	27	0.59	12	7.3	8.6	22.1
19	1.2	0.7	0.14	0.30	30	0.30	27	0.51	12	7.4	8.6	22.5
20	1.0	1.0	0.12	0.28	30	0.28	26	0.18	11	7.4	8.6	23.0
21	1.0	0.7	0.15	0.26	30	0.26	26	0.25	11	7.4	8.7	23.0
22	0.9	0.7	0.26	0.28	30	0.28	26	0.14	11	7.4	8.6	22.9
23	1.2	1.0	0.15	0.26	30	0.26	26	0.15	12	7.4	8.6	23.0
24	1.1	0.6	0.16	0.25	30	0.25	26	0.29	12	7.3	8.6	21.7
25	1.0	1.3	0.05	0.21	35	0.21	25	0.42	11	7.4	8.8	22.0
26	0.8	1.2	0.12	0.28	35	0.28	25	0.38	11	7.3	8.8	22.3
27	0.9	0.4	0.11	0.23	34	0.23	25	0.25	11	7.2	8.8	22.4
28	1.0	0.6	0.10	0.24	34	0.24	25	0.33	11	7.3	8.7	22.2
29	1.1	0.8	0.18	0.25	33	0.25	25	0.06	11	7.4	8.6	23.4
30	0.9	2.0	0.27	0.31	31	0.31	25	-	11	7.3	8.7	22.1
31	1.0	1.8	0.19	0.25	30	0.25	24	-	11	7.4	8.7	22.2

TABLE 2.2 (cont'd): PARTICULATE REMOVAL PROFILE (1985) OCTOBER/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	1.0	1.3	0.13	0.18	39	3	36	0.51	11	7.2	8.8	17.5
2	1.0	1.3	0.12	0.18	39	3	27	0.49	11	7.4	8.7	17.0
3	1.0	0.9	0.11	0.18	43	3	27	0.45	11	7.4	8.7	16.5
4	1.0	0.9	0.11	0.27	39	3	27	0.49	12	7.2	8.7	16.4
5	1.1	0.7	0.21	0.20	39	3	27	0.49	12	7.3	8.7	16.0
6	1.2	0.8	0.16	0.20	39	3	27	0.50	11	7.3	8.6	15.2
7	1.0	1.0	0.14	0.20	39	3	27	0.55	12	7.5	8.8	15.2
8	1.0	1.0	0.11	0.20	39	3	28	0.51	12	7.4	8.8	15.1
9	1.0	1.0	0.13	0.21	39	3	27	0.49	12	7.4	8.7	15.0
10	1.0	0.8	0.12	0.22	42	3	27	0.51	12	7.4	8.7	15.0
11	1.3	0.9	0.11	0.20	33	3	27	0.55	12	7.4	8.8	14.2
12	1.2	1.1	0.10	0.24	32	3	28	0.51	13	7.4	8.6	14.1
13	1.2	0.9	0.13	0.22	32	3	28	0.51	13	7.4	8.7	13.5
14	1.1	0.8	0.12	0.20	32	3	27	0.47	12	7.4	8.7	13.3
15	1.2	1.0	0.12	0.28	31	3	27	0.51	13	7.3	8.7	13.8
16	1.1	1.8	0.16	0.26	38	3	27	0.48	12	7.3	8.7	13.6
17	1.1	1.4	0.12	0.28	36	2	29	0.48	13	7.1	8.7	12.1
18	1.0	1.0	0.21	0.28	35	3	29	0.44	13	7.2	8.7	12.5
19	1.1	1.1	0.15	0.27	35	4	29	0.42	13	7.3	8.7	12.9
20	1.1	1.0	0.13	0.28	33	3	29	0.44	13	7.3	8.7	13.0
21	1.1	1.4	0.10	0.28	33	2	29	0.44	14	7.3	8.7	12.0
22	1.2	1.4	0.15	0.34	39	3	28	0.14	15	7.4	8.7	11.7
23	1.0	2.0	0.14	0.30	36	3	29	0.38	14	7.3	8.6	12.0
24	1.0	1.2	0.14	0.23	39	3	29	0.26	15	7.3	8.8	12.9
25	1.3	1.3	0.32	0.19	36	3	29	0.48	14	7.5	8.6	12.0
26	1.3	1.4	0.10	0.22	31	3	29	0.41	14	7.3	8.5	12.4
27	1.2	1.0	0.07	0.20	31	3	29	0.50	15	7.3	8.6	12.3
28	2.5	1.5	0.09	0.20	31	3	29	0.50	14	7.4	8.5	11.0
29	1.7	1.5	0.09	0.23	31	3	29	0.45	15	7.3	8.7	10.7
30	1.5	1.5	0.13	0.21	31	3	29	0.42	14	7.5	8.7	10.2
31	1.6	1.6	0.07	0.32	31	2	29	0.36	15	7.4	8.7	10.1

TABLE 2.3: PARTICULATE REMOVAL PROFILE (1984) JANUARY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	1.4	2.0	0.45	0.38	42	5	35	1.47	16	7.2	9.0	0.4
2	1.5	1.7	0.11	0.38	43	5	35	1.53	15	7.2	9.0	0.4
3	1.3	1.9	0.13	0.46	44	5	35	1.40	14	7.2	9.0	0.4
4	1.3	1.3	0.05	0.42	46	4	35	1.14	13	7.2	8.8	0.4
5	1.2	1.0	0.07	0.36	44	4	33	1.00	13	7.2	8.8	0.4
6	1.3	1.4	0.09	0.34	44	4	34	1.01	12	7.1	9.0	0.4
7	1.2	1.2	0.06	0.32	45	4	35	1.17	12	7.1	9.0	0.5
8	1.2	1.2	0.07	0.37	46	4	34	1.13	12	7.1	8.9	0.5
9	1.3	1.3	0.06	0.36	46	5	33	0.95	12	7.4	8.9	0.2
10	1.7	1.6	0.08	0.34	46	4	34	1.00	13	7.4	9.0	0.2
11	1.6	2.2	0.07	0.36	49	5	34	1.24	16	7.4	8.8	0.2
12	1.3	1.3	0.09	0.30	48	4	34	1.35	15	7.4	8.9	0.1
13	1.3	1.6	0.08	0.37	45	5	35	1.48	16	7.3	8.9	0.3
14	1.3	1.3	0.06	0.36	43	5	35	1.42	17	7.1	8.9	0.5
15	2.1	1.3	0.11	0.35	46	5	35	1.43	17	7.1	8.8	0.5
16	1.2	1.3	0.11	0.45	49	5	34	1.40	17	7.2	8.8	0.4
17	1.3	1.4	0.14	0.51	49	5	35	1.74	18	7.2	8.8	0.4
18	1.4	1.3	0.25	0.42	45	4	36	2.06	14	7.1	8.9	0.3
19	1.8	1.3	0.18	0.34	44	4	35	2.03	15	7.0	8.9	0.3
20	1.3	1.1	0.12	0.39	43	4	35	1.96	17	7.2	8.8	0.4
21	1.4	1.0	0.12	0.37	44	4	36	2.01	18	7.2	8.9	0.5
22	1.4	1.1	0.11	0.42	43	4	36	2.05	18	7.1	8.9	0.5
23	3.0	1.5	0.12	0.45	45	4	35	1.99	16	7.1	8.6	0.5
24	2.5	1.4	0.23	0.44	46	5	36	2.32	16	7.1	9.0	0.3
25	1.9	1.4	0.11	0.38	47	4	36	2.06	16	7.1	8.9	0.2
26	1.6	1.5	0.08	0.40	47	4	35	2.21	17	7.1	8.9	0.2
27	2.4	1.7	0.21	0.45	44	4	37	2.38	16	7.1	9.1	0.5
28	1.6	1.0	0.06	0.43	45	4	35	2.80	16	7.1	8.9	0.7
29	1.7	1.0	0.08	0.45	44	4	36	2.72	16	7.1	8.9	0.5
30	1.5	1.0	0.07	0.48	47	4	38	2.78	16	7.1	9.1	0.0
31	1.5	1.2	0.25	0.48	48	4	36	2.54	15	7.0	8.8	0.0

TABLE 2.3 (cont'd): PARTICULATE REMOVAL PROFILE (1984) MAY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	5.8	1.5	0.18	1.3	50	4	40	1.53	16	7.2	8.9	9.0
2	4.6	1.2	0.06	2.2	47	4	39	1.00	17	7.4	8.8	9.1
3	4.8	1.6	0.06	0.32	49	3	40	1.00	15	7.3	8.8	10.0
4	4.1	1.5	0.06	0.60	42	3	41	1.00	15	7.3	8.6	9.1
5	4.5	1.5	0.08	0.70	42	4	40	1.00	15	7.2	8.8	10.0
6	3.7	1.5	0.05	0.65	42	4	40	1.00	15	7.2	8.9	10.0
7	3.5	1.4	0.11	0.67	42	3	41	1.00	15	7.3	9.0	10.8
8	3.4	1.3	0.07	0.89	43	3	42	1.00	14	7.3	8.8	10.5
9	3.6	1.5	0.05	0.80	40	3	40	1.00	14	7.3	8.7	10.8
10	2.8	1.6	0.07	0.86	43	3	38	1.00	12	7.4	8.7	10.4
11	3.4	1.7	0.06	0.68	42	3	38	1.00	13	7.4	8.6	11.4
12	3.0	1.5	0.13	0.44	40	3	38	1.00	13	7.4	8.9	11.6
13	3.6	1.7	0.12	0.93	42	4	37	1.00	13	7.4	8.6	11.7
14	3.3	1.7	0.05	0.76	42	3	37	1.00	13	7.3	8.6	10.5
15	3.3	1.6	0.09	0.44	41	3	38	1.00	13	7.3	8.5	11.4
16	4.1	1.8	0.05	0.15	40	3	40	1.00	13	7.4	8.6	11.1
17	3.2	1.6	0.07	0.16	42	3	40	1.00	13	7.4	8.5	10.6
18	2.9	1.5	0.05	0.27	42	3	40	1.00	12	7.5	8.5	11.8
19	2.8	1.5	0.05	0.20	39	3	38	1.00	13	7.4	8.6	11.5
20	2.8	1.3	0.07	0.22	39	3	38	1.00	12	7.3	8.5	11.8
21	3.1	1.2	0.09	0.22	39	3	38	1.00	14	7.4	8.7	12.5
22	3.2	1.6	0.06	0.23	36	3	38	1.00	14	7.4	8.6	12.7
23	2.7	1.1	0.06	0.27	35	3	38	1.00	13	7.5	8.5	13.6
24	3.1	2.4	0.04	0.20	35	3	38	1.00	13	7.5	8.5	14.0
25	2.8	5.2	0.05	0.15	32	3	37	0.75	13	7.5	8.6	14.2
26	3.2	1.3	0.10	0.22	32	3	37	0.53	13	7.5	8.6	13.8
27	3.6	1.2	0.05	0.36	32	4	38	0.53	14	7.4	8.5	14.4
28	3.3	1.7	0.05	0.51	32	4	37	0.53	14	7.4	8.7	14.5
29	3.6	1.7	0.07	0.22	35	4	37	0.71	13	7.4	8.7	14.0
30	4.2	1.8	0.05	0.15	37	4	37	0.79	12	7.3	8.7	13.9
31	4.1	1.7	0.04	0.21	37	4	36	0.53	10	7.3	8.7	13.4

TABLE 2.3 (cont'd): PARTICULATE REMOVAL PROFILE (1984) JULY/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	5.5	2.2	0.17	1.17	38	3	23	0.39	10	7.3	8.7	20.2
2	4.3	1.8	0.16	0.16	39	3	23	0.39	10	7.3	8.7	20.6
3	4.5	2.4	0.17	0.17	39	4	23	0.47	10	7.2	8.7	21.2
4	4.9	2.7	0.12	0.12	39	4	24	0.42	10	7.0	8.6	21.1
5	4.9	2.4	0.23	0.23	41	4	24	0.23	12	7.1	8.7	22.1
6	2.4	2.8	0.22	0.22	41	4	25	0.42	10	7.1	8.5	22.0
7	4.8	1.7	0.24	0.24	40	5	24	0.20	14	7.0	8.7	21.5
8	5.0	1.9	0.23	0.23	39	4	24	0.36	13	7.1	8.4	21.1
9	5.8	3.9	0.15	0.15	39	4	25	0.41	11	7.1	8.6	20.7
10	5.2	2.3	0.23	0.23	41	4	24	0.45	13	7.2	8.6	20.4
11	5.3	4.1	0.20	0.20	36	4	23	0.53	13	7.2	8.7	20.4
12	5.3	1.6	0.22	0.22	44	4	24	0.72	13	7.2	8.6	20.1
13	5.4	2.5	0.16	0.16	41	5	24	0.94	12	7.1	8.7	20.9
14	5.8	3.2	0.22	0.22	39	4	23	0.67	12	7.1	8.7	21.5
15	6.2	2.7	0.22	0.22	39	4	24	0.97	12	7.2	8.5	11.4
16	5.8	3.2	0.18	0.18	39	3	24	0.76	13	7.2	8.6	21.5
17	7.0	2.5	0.17	0.17	35	4	26	1.03	13	7.2	8.8	21.5
18	3.0	1.0	0.18	0.18	35	3	25	0.69	13	7.2	8.7	21.5
19	3.0	1.0	0.16	0.16	35	4	24	0.70	12	7.2	8.6	21.5
20	2.5	1.0	0.15	0.15	37	4	24	0.91	12	7.3	8.7	21.8
21	3.0	1.0	0.26	0.26	38	4	25	0.95	12	7.3	8.7	22.2
22	2.8	1.7	0.25	0.25	38	4	25	0.88	12	7.2	8.6	22.5
23	2.4	0.9	0.18	0.18	38	4	25	0.44	12	7.4	8.6	22.5
24	2.7	2.2	0.19	0.19	37	4	25	0.98	12	7.3	8.6	21.0
25	3.3	1.3	0.17	0.17	37	4	25	1.05	12	7.3	8.7	21.9
26	3.2	1.3	0.14	0.14	39	4	25	1.05	12	7.3	8.7	22.0
27	3.2	0.9	0.18	0.18	37	3	24	0.41	10	7.3	8.7	22.0
28	2.9	1.2	0.17	0.17	36	4	25	0.79	12	7.2	8.6	21.8
29	2.5	1.2	0.15	0.15	36	4	25	0.88	12	7.3	8.6	22.0
30	2.3	1.6	0.18	0.18	36	4	25	0.47	12	7.2	8.6	22.0
31	2.5	2.0	0.17	0.17	37	4	25	0.97	10	7.2	8.7	22.0

TABLE 2.3 (cont'd): PARTICULATE REMOVAL PROFILE (1984) OCTOBER/BRITANNIA

DATE	TURBIDITY (FTU)				COLOUR (TCU)		COAGULANT	COAG. AID	LIME	pH		TEMP (°C)
	Raw	Set	Filter	Treat.	Raw	Treat.	mg/L	mg/L	mg/L	Raw	Treat.	
1	2.5	0.7	0.09	0.21	39	3	26	0.39	15	7.2	9.0	15.4
2	1.8	0.8	0.09	0.18	39	3	27	0.48	15	7.3	8.8	15.2
3	1.8	1.1	0.08	0.20	38	3	27	0.47	15	7.3	8.7	15.2
4	3.8	1.2	0.09	0.18	42	3	27	0.49	15	7.5	8.5	14.0
5	2.5	1.5	0.08	0.19	40	3	27	0.32	14	7.4	8.8	13.4
6	2.0	1.2	0.07	0.18	38	3	27	0.42	13	7.4	8.7	13.6
7	1.8	1.4	0.08	0.18	38	3	27	0.40	13	7.3	8.7	13.2
8	1.8	1.2	0.10	0.20	39	3	27	0.34	14	7.2	8.8	12.6
9	1.7	1.4	0.07	0.17	42	3	27	0.40	14	7.4	8.8	13.4
10	1.5	1.6	0.08	0.19	42	3	28	0.50	14	7.5	8.8	13.6
11	1.7	1.8	0.07	0.18	42	3	27	0.45	13	7.4	8.7	13.6
12	1.8	1.6	0.05	0.12	41	3	27	0.39	14	7.3	8.9	13.2
13	1.7	1.1	0.05	0.15	42	3	27	0.38	14	7.4	8.9	13.0
14	1.5	1.0	0.06	0.16	42	3	27	0.46	13	7.4	8.9	13.3
15	1.3	1.3	0.05	0.15	42	3	26	0.32	12	7.4	8.9	13.5
16	1.5	1.3	0.04	0.16	44	3	27	0.42	13	7.3	8.7	14.0
17	1.5	1.7	0.05	0.16	43	3	27	0.46	12	7.3	8.6	14.0
18	2.2	1.8	0.05	0.16	41	3	27	0.36	12	7.3	8.4	14.5
19	1.5	1.3	0.04	0.25	41	3	27	0.50	12	7.3	8.8	13.7
20	1.5	0.9	0.04	0.23	41	4	27	0.45	12	7.2	8.7	13.7
21	1.5	1.1	0.04	0.21	41	3	27	0.47	12	7.3	8.6	12.9
22	1.8	1.0	0.05	0.15	41	3	27	0.45	12	7.2	8.7	13.4
23	1.7	1.0	0.12	0.16	41	3	27	0.46	13	7.3	8.8	13.1
24	1.6	1.6	0.04	0.17	42	3	27	0.24	12	7.4	8.7	12.7
25	1.5	2.1	0.10	0.19	42	3	27	0.32	13	7.3	8.7	12.8
26	1.5	2.0	0.07	0.16	38	3	26	0.40	13	7.3	8.8	12.4
27	1.7	1.7	0.05	0.17	37	3	27	0.45	13	7.2	8.8	12.0
28	1.8	1.1	0.08	0.22	37	3	27	0.46	13	7.3	8.9	12.1
29	1.7	1.9	0.05	0.19	39	3	27	0.50	12	7.3	8.7	12.2
30	1.6	2.3	0.07	0.19	43	3	27	0.51	12	7.3	8.7	12.1
31	2.2	2.3	0.05	0.11	41	4	27	0.39	12	7.3	8.6	11.5

TABLE 3.0: DISINFECTION SUMMARY FOR BRITANNIA

MONTH	CHEMICAL	1986						1985						1984					
		PRE-			POST-			PRE-			POST-			PRE-			POST-		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JAN	Cl_2 Demand	0.98	0.62	0.95	0.56	0.00	0.07	0.89	0.46	-	0.40	0.01	-	1.10	0.56	-	0.77	0.15	-
	Cl_2 Dosage	1.20	0.90	1.10	0.95	0.58	0.82	1.23	0.69	0.90	1.05	0.69	0.90	1.46	0.83	1.15	1.08	0.79	0.96
	NH_3	0.22	0.22	0.22	0.22	0.22	0.22	0.35	0.35	0.35	0.17	0.17	0.17	-	-	-	-	-	-
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.19	0.06	0.10	0.90	0.90	0.90	0.40	0.11	0.19	0.90	0.90	0.90	0.30	0.06	0.14	0.90	0.90	0.90
	F-Dosage	-	-	-	0.86	0.33	0.80	-	-	-	0.90	0.90	0.90	-	-	-	0.81	0.70	0.79
	F-Res.	-	-	-	1.00	0.30	0.94	-	-	-	1.10	0.95	1.00	-	-	-	1.00	0.90	0.95
FEB	Cl_2 Demand	0.93	0.79	0.85	0.10	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-
	Cl_2 Dosage	1.00	0.90	0.95	0.93	0.64	0.76	1.06	0.89	0.97	1.12	0.70	0.88	1.10	0.96	1.00	1.10	0.81	0.97
	NH_3	0.68	0.68	0.68	0.61	0.61	0.61	0.41	0.41	0.41	0.24	0.24	0.24	0.01	0.01	0.01	0.05	0.05	0.05
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.15	0.06	0.10	0.90	0.90	0.90	0.32	0.16	0.24	0.90	0.90	0.90	0.35	0.12	0.25	0.90	0.90	0.90
	F-Dosage	-	-	-	0.83	0.00	0.66	-	-	-	0.90	0.90	0.90	-	-	-	0.80	0.55	0.78
	F-Res.	-	-	-	1.00	0.15	0.80	-	-	-	1.00	0.75	0.90	-	-	-	1.00	0.80	0.90
MAR	Cl_2 Demand	0.89	0.75	0.84	0.15	0.00	0.02	-	-	-	-	-	-	-	-	-	-	-	-
	Cl_2 Dosage	1.00	1.00	1.00	0.89	0.67	0.76	1.02	0.47	0.97	0.91	0.63	0.76	1.06	0.85	0.98	0.98	0.76	0.88
	NH_3	-	-	-	-	-	-	0.17	0.17	0.17	0.12	0.12	0.12	0.12	0.12	0.12	0.0	0.0	0.0
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.25	0.11	0.16	0.90	0.90	0.90	0.33	0.17	0.26	0.90	0.90	0.90	0.31	0.17	0.25	0.90	0.90	0.90
	F-Dosage	-	-	-	0.80	0.80	0.80	-	-	-	0.90	0.90	0.90	-	-	-	0.92	0.52	0.82
	F-Res.	-	-	-	1.05	0.95	1.00	-	-	-	1.10	0.95	1.01	-	-	-	1.00	0.50	0.90

TABLE 3.0 (cont'd): DISINFECTION SUMMARY FOR BRITANNIA

MONTH	CHEMICAL	1986						1985						1984					
		PRE-			POST-			PRE-			POST-			PRE-			POST-		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
APR	Cl_2 Demand	1.10	0.75	0.90	0.17	0.00	0.05	-	-	-	-	-	-	-	-	-	-	-	-
	Cl_2 Dosage	1.20	1.00	1.04	0.94	0.64	0.81	1.09	0.88	0.97	0.84	0.57	0.70	1.01	0.70	0.82	1.09	0.73	0.90
	NH_3	-	-	-	-	-	-	0.08	0.08	0.08	0.01	0.01	0.01	0.36	0.36	0.36	<.001	<.001	<.001
	O_2	2.6	2.6	2.6	17.0	17.0	17.0	12.0	12.0	12.0	30.0	30.0	30.0	12.0	12.0	12.0	30.0	30.0	30.0
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.25	0.10	0.14	0.90	0.90	0.90	0.36	0.16	0.25	0.90	0.90	0.90	0.21	0.09	0.15	0.90	0.90	0.90
	F-Dosage	-	-	-	0.82	0.80	0.81	-	-	-	0.89	0.89	0.89	-	-	-	1.01	0.82	0.88
	F-Res.	-	-	-	1.05	0.25	0.94	-	-	-	1.05	0.90	1.00	-	-	-	1.05	0.80	0.95
MAY	Cl_2 Demand	1.36	0.96	1.15	0.44	0.00	0.00	0.97	0.57	-	0.63	0.14	-	0.99	0.65	-	0.48	0.22	-
	Cl_2 Dosage	1.60	1.20	1.26	0.95	0.60	0.75	1.24	0.97	1.09	1.02	0.77	0.90	1.25	0.97	1.04	1.05	0.85	0.99
	NH_3	-	-	-	-	-	-	0.33	0.33	0.33	0.17	0.17	0.17	0.13	0.13	0.13	0.11	0.11	0.11
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.15	0.05	0.11	0.90	0.90	0.90	0.28	0.08	0.18	0.90	0.90	0.90	0.19	0.05	0.14	0.90	0.90	0.90
	F-Dosage	-	-	-	0.82	0.80	0.81	-	-	-	0.89	0.88	0.89	-	-	-	0.88	0.16	0.84
	F-Res.	-	-	-	1.00	0.90	0.99	-	-	-	1.05	0.90	0.94	-	-	-	1.15	0.95	1.00
JUN	Cl_2 Demand	2.41	1.55	2.15	0.20	0.00	0.05	-	-	-	-	-	-	-	-	-	-	-	-
	Cl_2 Dosage	2.48	1.60	2.23	1.10	0.67	0.89	1.83	1.16	1.37	1.02	0.77	0.88	2.12	1.07	1.69	1.19	0.76	1.03
	NH_3	-	-	-	-	-	-	0.44	0.44	0.44	0.38	0.38	0.38	0.13	0.13	0.13	0.14	0.14	0.14
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.10	0.05	0.08	1.00	0.90	0.92	0.22	0.05	0.10	0.90	0.90	0.90	0.13	0.04	0.08	0.90	0.90	0.90
	F-Dosage	-	-	-	0.81	0.25	0.77	-	-	-	0.88	0.87	0.87	-	-	-	0.86	0.56	0.83
	F-Res.	-	-	-	1.10	0.95	1.01	-	-	-	1.00	0.90	1.00	-	-	-	1.10	0.15	0.93

TABLE 3.0 (cont'd): DISINFECTION SUMMARY FOR BRITANNIA

MONTH	CHEMICAL	1986						1985						1984					
		PRE-			POST-			PRE-			POST-			PRE-			POST-		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
JUL	Cl_2 Demand	3.89	2.52	3.13	0.48	0.00	0.16	1.46	0.97	-	0.80	0.33	-	1.52	1.02	-	1.36	0.61	-
	Cl_2 Dosage	4.00	2.60	3.34	1.44	0.76	1.09	2.08	1.70	1.85	0.94	0.76	0.86	2.08	1.96	2.02	1.21	1.01	1.10
	NH_3	-	-	-	-	-	-	-	-	-	-	-	-	0.37	0.37	0.37	0.27	0.27	0.27
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.44	0.08	0.21	1.40	1.00	1.14	0.11	0.04	0.07	0.90	0.90	0.90	0.10	0.05	0.07	0.90	0.90	0.90
	F-Dosage	-	-	-	0.81	0.29	0.77	-	-	-	0.87	0.87	0.87	-	-	-	0.85	0.85	0.85
	F-Res.	-	-	-	1.05	0.05	0.76	-	-	-	1.00	0.85	0.95	-	-	-	1.10	0.95	1.00
AUG	Cl_2 Demand	3.51	2.92	3.21	0.43	0.00	0.17	-	-	-	-	-	-	-	-	-	-	-	-
	Cl_2 Dosage	3.80	3.29	3.55	1.45	0.89	1.23	2.24	1.75	1.95	1.26	0.84	1.01	2.30	2.06	2.21	1.18	0.94	1.07
	NH_3	-	-	-	-	-	-	-	-	-	-	-	-	1.40	1.04	1.04	1.23	1.23	1.23
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.51	0.19	0.34	1.40	1.40	1.40	0.12	0.05	0.08	0.90	0.90	0.90	0.08	0.04	0.06	0.91	0.90	0.90
	F-Dosage	-	-	-	0.81	0.00	0.44	-	-	-	0.87	0.87	0.87	-	-	-	0.85	0.54	0.84
	F-Res.	-	-	-	1.05	0.05	0.55	-	-	-	1.05	0.90	1.00	-	-	-	1.05	0.20	0.95
SEP	Cl_2 Demand	3.25	2.48	2.89	0.27	0.00	0.00	-	-	-	-	-	-	-	-	-	-	-	-
	Cl_2 Dosage	3.40	2.80	3.18	1.40	0.88	1.09	1.90	1.72	1.82	1.09	0.89	0.99	2.32	2.18	2.23	1.24	0.86	1.06
	NH_3	-	-	-	-	-	-	0.66	0.66	0.66	0.26	0.26	0.26	.131	.131	.131	0.06	0.06	0.06
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.48	0.15	0.29	1.40	1.40	1.40	0.12	0.05	0.08	0.90	0.90	0.90	0.10	0.06	0.08	0.90	0.90	0.90
	F-Dosage	-	-	-	0.90	0.84	0.88	-	-	-	0.87	0.87	0.87	-	-	-	0.85	0.85	0.85
	F-Res.	-	-	-	1.10	0.95	1.04	-	-	-	1.00	0.90	0.95	-	-	-	1.20	0.85	1.00

TABLE 3.0 (cont'd): DISINFECTION SUMMARY FOR BRITANNIA

MONTH	CHEMICAL	1986						1985						1984					
		PRE-			POST-			PRE-			POST-			PRE-			POST-		
		Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.
OCT	Cl_2 Demand	2.00	1.24	-	1.22	0.15	-	1.32	0.97	-	0.89	0.38	-	1.48	0.96	-	1.12	0.57	-
	Cl_2 Dosage	3.00	2.80	2.89	1.26	0.90	1.12	1.90	1.67	1.81	1.09	0.79	0.94	2.15	1.76	1.88	1.15	0.92	1.01
	NH_3	0.34	0.34	0.34	0.23	0.23	0.23	-	-	-	-	-	-	0.18	0.18	0.18	0.11	0.11	0.11
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.48	0.16	0.27	1.45	1.40	1.40	0.10	0.05	0.08	0.90	0.90	0.90	0.10	0.06	0.08	0.90	0.90	0.90
	F-Dosage	-	-	-	0.91	0.90	0.91	-	-	-	0.87	0.87	0.87	-	-	-	0.86	0.85	0.85
	F-Res.	-	-	-	1.05	0.95	1.00	-	-	-	1.00	0.90	0.95	-	-	-	1.20	0.95	1.10
NOV	Cl_2 Demand																		
	Cl_2 Dosage	2.80	2.20	2.54	1.35	0.83	1.09	1.80	1.40	1.73	1.08	0.40	0.86	1.85	1.58	1.70	1.10	0.91	1.01
	NH_3	-	-	-	-	-	-	0.39	0.39	0.39	0.36	0.36	0.36	0.34	0.34	0.34	0.19	0.19	0.19
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.74	0.16	0.13	1.40	1.40	1.40	0.11	0.07	0.08	0.90	0.90	0.90	0.12	0.06	0.07	0.90	0.90	0.90
	F-Dosage	-	-	-	0.91	0.91	0.91	-	-	-	0.88	0.87	0.87	-	-	-	0.88	0.86	0.87
	F-Res.	-	-	-	1.05	0.90	0.99	-	-	-	1.00	0.65	0.90	-	-	-	1.05	0.60	1.00
DEC	Cl_2 Demand																		
	Cl_2 Dosage	2.20	1.60	1.98	1.33	0.95	1.15	1.40	1.20	1.38	1.05	0.70	0.82	1.78	1.34	1.60	2.11	0.92	1.00
	NH_3	-	-	-	-	-	-	0.36	0.36	0.36	0.24	0.24	0.24	0.31	0.31	0.31	0.14	0.14	0.14
	Cl_2 Res.(Free)																		
	Cl_2 Res.(Comb)																		
	Cl_2 Res.(Total)	0.50	0.25	0.35	1.40	1.40	1.40	0.14	0.07	0.11	0.90	0.90	0.90	0.29	0.06	0.17	0.90	0.90	0.90
	F-Dosage	-	-	-	0.91	0.91	0.91	-	-	-	0.88	0.87	0.87	-	-	-	0.88	0.86	0.87
	F-Res.	-	-	-	1.05	0.95	1.00	-	-	-	-	-	-	-	-	-	1.00	0.05	0.75

TABLE 3.1: DISINFECTION PROFILE FOR BRITANNIA/JANUARY 1986

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	0.94	1.20	-	-	.10	.16	.26	0.27	0.91	-	-	.88	.02	0.90	0.86	0.90
2	0.93	1.20	-	-	.16	.11	.27	0.09	0.87	-	-	.88	.17	1.05	0.51	0.75
3	0.88	1.20	-	-	.18	.14	.32	0.26	0.86	-	-	.87	.05	0.92	0.86	NS
4	0.97	1.20	-	-	.13	.10	.23	0.13	0.81	-	-	.88	.03	0.91	0.86	0.90
5	0.94	1.20	-	-	-	-	.26	0.31	0.95	-	-	.86	.04	0.90	0.85	0.95
6	0.98	1.20	-	-	.15	.07	.22	(0.03)	0.80	-	-	.88	.17	1.05	0.85	0.95
7	0.97	1.20	-	-	.12	.11	.23	0.04	0.73	-	-	.80	.12	0.92	0.85	0.95
8	0.92	1.20	-	-	.12	.16	.28	0.11	0.77	-	-	.88	.06	0.94	0.86	0.95
9	0.85	1.20	-	-	.19	.16	.35	0.35	0.90	-	-	.85	.05	0.90	0.85	0.90
10	0.89	1.20	-	-	.15	.16	.31	0.21	0.80	-	-	.85	.05	0.90	0.85	0.95
11	0.88	1.20	-	-	.17	.15	.32	0.24	0.83	-	-	.88	.03	0.91	0.85	0.95
12	0.89	1.20	-	-	.16	.15	.31	0.18	0.77	-	-	.81	.09	0.90	0.85	1.00
13	0.89	1.20	-	-	.16	.15	.31	0.18	0.79	-	-	.87	.05	0.92	0.85	1.00
14	0.91	1.20	-	-	.14	.15	.29	0.24	0.85	-	-	.78	.12	0.90	0.85	1.00
15	0.88	1.20	0.22		.15	.17	.32	0.19	0.75	0.22		.73	.15	0.88	0.85	1.00
16	0.94	1.20	-	-	.12	.14	.26	0.27	0.90	-	-	.71	.18	0.89	0.83	1.00
17	0.88	1.20	-	-	.17	.15	.32	0.16	0.76	-	-	.68	.24	0.92	0.83	1.00
18	0.91	1.20	-	-	.18	.11	.29	0.29	0.80	-	-	-	-	0.80	0.83	NS
19	0.62	1.20	-	-	.15	.43	.58	0.56	0.89	-	-	.64	.27	0.91	0.83	NS
20	0.87	1.20	-	-	.16	.17	.33	0.22	0.80	-	-	.55	.36	0.91	0.83	0.95
21	0.71	1.07	-	-	.14	.22	.36	0.33	0.86	-	-	.59	.30	0.89	0.83	0.95
22	0.71	1.00	-	-	.09	.20	.29	0.31	0.95	-	-	.63	.30	0.93	0.83	0.90
23	0.68	1.00	-	-	.11	.21	.32	0.22	0.83	-	-	.71	.22	0.93	0.83	0.95
24	0.72	0.90	-	-	.12	.06	.18	0.17	0.90	-	-	.53	.38	0.91	0.83	NS
25	0.70	0.90	-	-	.10	.10	.20	0.05	0.73	-	-	.64	.24	0.88	0.57	0.45
26	0.68	0.90	-	-	.11	.11	.22	(0.12)	0.58	-	-	.62	.30	0.92	-	0.80
27	0.66	0.90	-	-	.19	.05	.24	0.23	0.86	-	-	.42	.45	0.87	0.41	0.70
28	0.63	0.90	-	-	.18	.09	.27	0.06	0.70	-	-	.49	.42	0.91	0.83	0.90
29	0.65	0.90	-	-	.09	.06	.25	0.10	0.77	-	-	.44	.48	0.92	0.83	0.90
30	0.68	0.90	-	-	.12	.10	.22	0.12	0.78	-	-	.61	.27	0.88	0.83	0.95
31	0.65	0.90	-	-	.13	.12	.25	0.14	0.80	-	-	.41	.50	0.91	0.36	0.95

TABLE 3.1: DISINFECTION PROFILE FOR BRITANNIA/MAY 1986

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	1.00	1.20	-	-	.09	.11	.20	0.18	0.84	-	-	.63	.23	0.86	0.82	1.00
2	0.98	1.20	-	-	.13	.09	.22	0.18	0.84	-	-	.58	.30	0.88	0.82	0.95
3	1.00	1.20	-	-	.06	.14	.20	0.21	0.88	-	-	.64	.23	0.87	0.82	0.95
4	1.01	1.20	-	-	.07	.12	.19	0.16	0.85	-	-	.63	.25	0.88	0.82	1.00
5	0.98	1.20	-	-	.10	.12	.22	0.23	0.84	-	-	.56	.27.	0.83	0.82	0.95
6	0.96	1.20	-	-	.13	.11	.24	0.17	0.75	-	-	.63	.19	0.82	0.82	0.95
7	0.99	1.20	-	-	.14	.07	.21	(0.01)	0.68	-	-	-	-	0.90	0.82	1.00
8	1.03	1.20	-	-	.10	.07	.17	0.10	0.79	-	-	.60	.26	0.86	0.81	1.00
9	1.00	1.20	-		.09	.11	.20	0.06	0.75	-		.62	.27	0.89	0.81	1.00
10	0.97	1.20	-	-	.13	.10	.23	0.11	0.73	-	-	.65	.20	0.85	0.81	1.00
11	1.00	1.20	-	-	.09	.11	.20	0.04	0.74	-	-	.75	.15	0.90	0.81	1.00
12	1.02	1.20	-	-	.09	.09	.18	0.11	0.79	-	-	.69	.17	0.86	0.81	1.00
13	1.00	1.20	-	-	.12	.08	.20	0.14	0.83	-	-	.54	.35	0.89	0.81	1.00
14	0.98	1.20	-	-	.12	.10	.22	0.21	0.87	-	-	.77	.11	0.88	0.81	1.00
15	0.98	1.20	-	-	.15	.07	.22	0.07	0.74	-	-	.62	.27	0.89	0.81	1.00
16	0.97	1.20	-	-	.08	.15	.23	0.25	0.89	-	-	.61	.26	0.87	0.81	1.00
17	0.98	1.20	-	-	.12	.10	.22	0.11	0.76	-	-	.62	.25	0.87	0.81	1.00
18	1.02	1.20	-	-	.08	.10	.18	0.07	0.74	-	-	.63	.22	0.85	0.81	1.00
19	1.03	1.20	-	-	.06	.11	.17	0.12	0.84	-	-	.68	.21	0.89	0.81	1.00
20	0.97	1.20	-	-	.10	.13	.23	(0.01)	0.66	-	-	.53	.37	0.90	0.81	1.00
21	1.02	1.20	-	-	.08	.10	.18	0.07	0.71	-	-	.47	.35	0.82	0.80	1.00
22	0.99	1.20	-	-	.11	.10	.21	(0.03)	0.64	-	-	.55	.33	0.88	0.80	1.00
23	1.07	1.25	-	-	.08	.10	.18	0.09	0.71	-	-	.62	.18	0.80	0.80	0.90
24	1.02	1.40	-	-	.17	.21	.38	0.07	0.67	-	-	-	-	0.98	0.80	0.90
25	1.10	1.40	-	-	.13	.17	.30	0.07	0.63	-	-	.62	.24	0.86	0.80	1.00
26	1.15	1.40	-	-	.13	.12	.25	0.00	0.60	-	-	.63	.22	0.85	0.80	1.00
27	1.22	1.40	-	-	.09	.09	.18	(0.07)	0.63	-	-	.80	.08	0.88	0.80	1.00
28	1.14	1.40	-	-	.08	.18	.26	0.29	0.95	-	-	.86	.06	0.92	0.80	1.00
29	1.05	1.40	-	-	.13	.22	.35	0.44	0.94	-	-	.63	.22	0.85	0.80	1.00
30	1.27	1.50	-	-	.07	.16	.23	(0.01)	0.68	-	-	.73	.19	0.92	0.80	1.00
31	1.36	1.60	-	-	.06	.18	.24	0.13	0.78	-	-	.78	.11	0.89	0.80	1.00

TABLE 3.1: DISINFECTION PROFILE FOR BRITANNIA/JULY 1986

DATE	PRE CHLORINATION Cl_2 Dem.	PRE CHLORINATION Cl_2 Dos.	PRE CHLORINATION NH_3	PRE CHLORINATION SO_2	PRE CHLORINATION RESIDUAL Cl_2 Free	PRE CHLORINATION RESIDUAL Cl_2 Comb.	PRE CHLORINATION RESIDUAL Cl_2 Total	POST-CHLORINATION Cl_2 Dem.	POST-CHLORINATION Cl_2 Dos.	POST-CHLORINATION NH_3	POST-CHLORINATION SO_2	POST-CHLORINATION RESIDUAL Cl_2 Free	POST-CHLORINATION RESIDUAL Cl_2 Comb.	POST-CHLORINATION RESIDUAL Cl_2 Total	FLUORIDE Dos.	FLUORIDE Res.
1	1.47	2.60	-	-	0.91	.22	1.13	0.87	0.82	-	-	.92	.16	1.08	0.81	1.00
2	1.93	2.60	-	-	0.38	.29	0.67	0.84	1.14	-	-	.83	.14	0.97	0.81	1.00
3	1.74	2.60	-	-	0.75	.11	0.86	0.84	1.06	-	-	1.01	.07	1.08	0.81	1.00
4	1.74	2.60	-	-	0.53	.33	0.86	0.84	0.98	-	-	1.92	.08	1.00	0.81	1.00
5	1.72	2.60	-	-	0.52	.36	0.88	0.94	1.09	-	-	0.96	.07.	1.03	0.81	1.00
6	1.52	2.60	-	-	0.76	.32	1.08	1.08	1.04	-	-	0.98	.06	1.04	0.81	1.00
7	1.60	2.60	-	-	0.71	.29	1.00	1.12	1.12	-	-	0.90	.10	1.00	0.81	1.00
8	1.62	2.60	-	-	0.75	.23	0.98	1.10	1.09	-	-	0.91	.06	0.97	0.47	1.00
9	1.83	2.77	-	-	0.45	.49	0.94	0.98	1.02	-	-	0.75	.23	0.98	0.81	1.00
10	1.53	3.35	-	-	1.67	.15	1.82	1.78	0.95	-	-	0.73	.26	0.99	0.81	1.05
11	1.60	4.00	-	-	1.65	.75	2.40	2.36	0.93	-	-	0.75	.22	0.97	0.81	1.00
12	1.66	4.00	-	-	1.97	.37	2.34	2.20	0.85	-	-	0.79	.20	0.99	0.81	1.00
13	1.50	4.00	-	-	2.00	.50	2.50	2.36	0.88	-	-	0.92	.10	1.02	0.81	1.00
14	1.84	4.00	-	c	1.95	.21	2.16	2.13	1.01	-		0.95	.09	1.04	0.81	1.00
15	1.49	3.69	-	-	1.90	.30	2.20	1.89	0.76	-	-	0.94	.13	1.07	0.81	1.05
16	1.70	3.60	-	-	1.55	.35	1.90	1.77	0.87	-	-	0.95	.05	1.00	0.81	1.05
17	1.75	3.60	-	-	1.75	.10	1.85	1.76	0.97	-	-	0.93	.13	1.06	0.81	1.00
18	1.70	3.60	-	-	1.70	.20	1.90	1.65	1.02	-	-	1.15	.12	1.27	0.81	1.00
19	1.61	3.54	-	-	1.82	.11	1.93	2.02	1.24	-	-	1.05	.10	1.27	0.81	1.00
20	1.92	3.40	-	-	1.13	.35	1.48	1.22	0.93	-	-	1.11	.08	1.19	0.81	1.00
21	1.80	3.40	-	-	1.45	.15	1.60	1.65	1.20	-	-	1.02	.13	1.15	0.80	1.00
22	1.77	3.40	-	-	1.55	.08	1.63	1.67	1.16	-	-	1.00	.12	1.12	0.80	1.00
23	1.77	3.40	-	-	1.35	.28	1.63	1.59	1.06	-	-	0.90	.20	1.10	0.29	1.00
24	1.70	3.40	-	-	1.50	.20	1.70	1.67	1.22	-	-	1.15	.10	1.25	0.29	0.05
25	1.68	3.40	-	-	1.50	.22	1.72	1.57	1.18	-	-	1.15	.18	1.33	0.29	0.05
26	1.98	3.60	-	-	1.42	.20	1.62	1.54	1.42	-	-	1.40	.10	1.50	0.29	0.05
27	2.02	3.60	-	-	1.36	.22	1.58	1.59	1.44	-	-	1.36	.07	1.43	0.29	0.05
28	2.03	3.60	-	-	1.40	.17	1.57	1.43	1.36	-	-	1.40	.10	1.50	0.29	0.05
29	1.59	3.72	-	-	1.94	.19	2.13	2.03	1.38	-	-	1.43	.05	1.48	0.29	0.05
30	1.80	3.80	-	-	1.50	.50	2.00	1.74	1.39	-	-	1.45	.20	1.65	0.29	0.05
31	1.65	3.80	-	-	1.75	.40	2.15	2.09	1.31	-	-	1.13	.24	1.37	0.29	0.05

TABLE 3.1: DISINFECTION PROFILE FOR BRITANNIA/OCTOBER 1986

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	1.90	3.00	-	-	0.60	.50	1.10	0.94	1.09	-	-	1.20	.05	1.25	0.90	1.00
2	1.60	3.00	-	-	1.07	.33	1.40	1.04	1.04	-	-	1.25	.15	1.40	0.90	0.95
3	1.65	3.00	-	-	1.15	.20	1.35	1.09	1.19	-	-	1.30	.15	1.45	0.90	0.95
4	1.85	3.00	-	-	0.89	.26	1.15	0.15	0.38	-	-	1.25	.13	1.38	0.90	1.00
5	1.85	3.00	-	-	0.98	.17	1.15	0.81	1.10	-	-	1.38	.06.	1.44	0.90	1.00
6	1.70	3.00	-	-	1.26	.04	1.30	0.96	1.14	-	-	1.36	.12	1.48	0.90	1.00
7	2.00	3.00	0.34	-	0.78	.22	1.00	0.84	1.26	0.23	-	1.35	.07	1.42	0.90	1.00
8	1.80	3.00	-	-	1.07	.13	1.20	0.87	1.12	-	-	1.39	.06	1.45	0.90	1.00
9	1.85	3.07	-	-	1.00	.15	1.15	0.72	1.07	-	-	1.40	.10	1.50	0.90	1.00
10	1.95	2.80	-	-	0.73	.12	0.85	0.61	1.16	-	-	1.27	.13	1.40	0.90	1.00
11	1.61	3.00	-	-	1.32	.07	1.39	1.10	1.13	-	-	1.35	.07	1.42	0.90	1.05
12	1.65	3.00	-	-	1.18	.17	1.35	1.10	1.22	-	-	1.41	.06	1.47	0.90	1.05
13	1.24	2.84	-	-	1.41	.19	1.60	1.10	0.90	-	-	1.34	.06	1.40	0.90	1.05
14	1.65	2.80	-	-	1.00	.15	1.15	0.90	1.21	-	-	-	-	1.46	0.90	1.05
15	1.65	2.80	-	-	1.05	.10	1.15	0.81	1.10	-	-	1.35	.09	1.44	0.91	1.00
16	1.60	2.80	-	-	1.10	.10	1.20	0.83	1.11	-	-	1.17	.31	1.48	0.91	1.00
17	1.65	2.80	-	-	1.05	.10	1.15	0.90	1.10	-	-	1.25	.10	1.35	0.91	1.00
18	1.80	2.80	-	-	0.90	.10	1.00	0.65	1.05	-	-	1.20	.20	1.40	0.91	1.00
19	1.77	2.92	-	-	0.90	.25	1.15	0.80	1.05	-	-	1.25	.15	1.40	0.91	1.00
20	1.65	3.00	-	-	1.14	.21	1.35	1.02	1.05	-	-	1.24	.14	1.38	0.91	1.00
21	1.55	3.00	-	-	1.11	.34	1.45	1.11	1.09	-	-	1.33	.10	1.43	0.91	0.95
22	1.76	2.92	-	-	0.94	.22	1.16	0.46	1.00	-	-	1.51	.19	1.70	0.91	0.95
23	1.58	2.80	-	-	1.05	.17	1.22	0.62	1.03	-	-	1.51	.12	1.63	0.91	1.00
24	1.45	2.80	-	-	1.05	.30	1.35	0.97	1.12	-	-	1.47	.03	1.50	0.91	1.00
25	1.38	2.80	-	-	1.08	.34	1.42	1.22	1.24	-	-	1.34	.10	1.44	0.91	1.05
26	1.36	2.80	-	-	1.10	.34	1.44	1.21	1.19	-	-	1.30	.12	1.42	0.91	1.00
27	1.55	2.80	-	-	1.06	.19	1.25	1.08	1.21	-	-	1.17	.21	1.38	0.91	1.00
28	1.67	2.80	-	0.0[illegible]	0.95	.18	1.13	0.80	1.14	-	[illegible]	1.34	.13	1.47	0.91	1.00
29	1.77	2.80	-	-	0.84	.19	1.03	0.70	1.08	-	-	1.33	.08	1.41	0.91	1.00
30	1.58	2.80	-	-	0.87	.35	1.22	1.08	1.25	-	-	1.24	.15	1.39	0.91	1.00
31	1.47	2.80	-	-	0.73	.60	1.33	1.11	1.20	-	-	1.29	.13	1.42	0.91	1.00

TABLE 3.2: DISINFECTION PROFILE FOR BRITANNIA/JANUARY 1985

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	0.89	1.22	-	-	0.08	.25	0.33	0.39	0.99	-	-	0.68	.25	0.93	0.90	1.05
2	0.71	1.23	-	-	0.33	.19	0.52	0.34	0.92	-	-	0.73	.37	1.10	0.90	1.05
3	0.65	1.01	-	-	0.09	.27	0.36	0.37	0.91	-	-	0.35	.55	0.90	0.90	1.05
4	0.73	1.01	-	-	0.19	.09	0.28	0.31	0.91	-	-	0.57	.31	0.88	0.90	1.10
5	0.62	0.88	-	-	0.18	.08	0.26	0.21	0.86	-	-	0.58	.33.	0.91	0.90	1.10
6	0.61	0.85	-	-	0.19	.05	0.24	0.25	0.91	-	-	0.70	.20	0.90	0.90	1.05
7	0.53	0.77	-	-	0.11	.13	0.24	0.19	0.85	-	-	0.47	.43	0.90	0.90	1.05
8	0.61	0.83	-	-	0.02	.20	0.22	0.19	0.88	-	-	0.61	.30	0.91	0.90	1.00
9	0.54	0.75	-	-	0.08	.13	0.21	0.28	0.98	-	-	0.63	.28	0.91	0.90	1.05
10	0.50	0.69	-	-	0.12	.07	0.19	0.01	0.69	-	-	0.58	.29	0.87	0.90	1.10
11	0.56	0.75	-	-	0.08	.11	0.19	0.09	0.86	-	-	0.58	.38	0.96	0.90	1.00
12	0.46	0.74	-	-	0.03	.25	0.28	0.26	0.90	-	-	0.83	.09	0.92	0.90	1.00
13	0.54	0.73	-	-	0.13	.06	0.19	0.18	0.88	-	-	0.81	.08	0.89	0.90	1.00
14	0.60	0.79	-	-	0.06	.13	0.19	0.23	0.91	-	-	0.57	.30	0.87	0.90	1.00
15	0.63	0.84	0.35	-	0.07	.14	0.21	0.15	0.80	0.17	-	0.54	.32	0.86	0.90	1.05
16	0.64	0.82	-	-	0.09	.09	0.18	0.09	0.79	-	-	0.62	.26	0.88	0.90	1.05
17	0.53	0.71	-	-	0.09	.09	0.18	0.23	0.98	-	-	0.53	.40	0.93	0.90	1.00
18	0.58	0.74	-	-	0.01	.15	0.16	0.32	0.87	-	-	0.35	.36	0.71	0.90	1.00
19	0.69	0.86	-	-	0.03	.14	0.17	0.10	0.81	-	-	-	-	0.88	0.90	1.00
20	0.77	1.01	-	-	0.10	.14	0.24	0.30	0.93	-	-	0.52	.35	0.87	0.90	0.95
21	0.71	0.95	-	-	0.12	.12	0.24	0.28	0.89	-	-	0.76	.09	0.85	0.90	1.05
22	0.61	0.95	-	-	0.10	.18	0.28	0.22	0.92	-	-	0.75	.23	0.98	0.90	1.00
23	0.69	0.95	-	-	0.09	.17	0.26	0.22	0.86	-	-	0.65	.25	0.90	0.90	1.00
24	0.60	0.93	-	-	0.11	.22	0.33	0.35	0.87	-	-	0.44	.41	0.85	0.90	NS
25	0.67	0.92	-		0.13	.12	0.25	0.32	0.94	-		0.58	.29	0.87	0.90	NS
26	0.74	1.00	-	-	0.14	.12	0.26	0.40	1.05	-	-	0.61	.30	0.91	0.90	1.00
27	0.73	1.00	-	-	0.16	.11	0.27	0.40	1.02	-	-	0.62	.27	0.89	0.90	1.00
28	0.73	1.00	-	-	0.13	.14	0.27	0.33	0.95	-	-	0.60	.29	0.89	0.90	1.00
29	0.67	0.98	-	-	0.12	.19	0.31	0.40	0.92	-	-	0.49	.34	0.83	0.90	0.95
30	0.68	0.98	-	-	0.14	.16	0.30	0.28	0.86	-	-	0.69	.19	0.88	0.90	0.95
31	0.65	0.92	-	-	0.11	.16	0.27	0.37	1.00	-	-	0.58	.32	0.90	0.90	0.95

TABLE 3.2: DISINFECTION PROFILE FOR BRITANNIA/MAY 1985

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	0.60	1.02	-	-	0.28	.14	0.42	0.45	0.93	-	-	0.65	.25	0.90	0.89	0.9
2	0.72	1.03	-	-	0.17	.14	0.31	0.30	0.89	-	-	0.66	.24	0.90	0.89	0.90
3	0.79	1.05	-	-	0.14	.12	0.26	0.16	0.81	-	-	0.67	.24	0.91	0.89	0.90
4	0.75	1.03	-	-	0.16	.12	0.28	0.30	0.93	-	-	0.85	.05	0.90	0.89	0.90
5	0.74	1.02	-	-	0.17	.11	0.28	0.24	0.86	-	-	0.75	.14	0.89	0.89	0.90
6	0.69	0.98	-	-	0.13	.16	0.29	0.31	0.91	-	-	0.80	.09	0.89	0.89	0.95
7	0.72	0.98	-	-	0.13	.13	0.26	0.21	0.84	-	-	0.73	.16	0.89	0.89	0.90
8	0.66	0.98	-	-	0.15	.17	0.32	0.38	0.95	-	-	0.78	.13	0.91	0.89	0.95
9	0.66	1.01	-	-	0.16	.19	0.35	0.35	0.91	-	-	0.77	.14	0.91	0.89	0.90
10	0.77	1.03	-	-	0.17	.09	0.26	0.35	1.00	-	-	0.75	.17	0.92	0.89	0.90
11	0.68	1.00	-	-	0.11	.21	0.32	0.28	0.88	-	-	0.72	.19	0.91	0.89	0.90
12	0.65	1.00	-	-	0.13	.22	0.35	0.23	0.79	-	-	0.73	.19	0.92	0.89	0.90
13	0.71	1.00	-	-	0.05	.24	0.29	0.14	0.77	-	-	0.77	.15	0.92	0.89	0.90
14	0.74	1.03	0.33	-	0.21	.08	0.29	0.29	0.92	0.17	-	0.76	.14	0.90	0.89	0.90
15	0.79	1.08	-	-	0.11	.18	0.29	0.32	0.93	-	-	0.86	.05	0.91	0.89	0.90
16	0.71	0.99	-	-	0.12	.16	0.28	0.29	0.92	-	-	0.86	.05	0.91	0.89	0.90
17	0.72	0.99	-	-	0.15	.12	0.27	0.23	0.87	-	-	0.78	.10	0.88	0.89	0.90
18	0.84	1.06	-	-	0.13	.09	0.22	0.17	0.83	-	-	0.83	.08	0.91	0.89	1.00
19	0.90	1.08	-	-	0.04	.14	0.18	0.23	0.96	-	-	0.74	.15	0.89	0.89	1.00
20	0.89	1.20	-	-	0.12	.19	0.31	0.40	0.98	-	-	0.81	.11	0.92	0.89	1.00
21	0.97	1.23	-	-	0.06	.20	0.26	0.27	0.93	-	-	0.77	.16	0.93	0.89	1.05
22	0.76	1.21	-	-	0.21	.24	0.45	0.37	0.85	-	-	0.83	.02	0.85	0.88	0.90
23	0.85	1.19	-	-	0.08	.26	0.34	0.50	1.01	-	-	0.84	.05	0.89	0.88	0.95
24	0.96	1.23	-	-	0.12	.15	0.27	0.30	0.92	-	-	0.73	.13	0.86	0.88	1.00
25	0.88	1.21	-	-	0.21	.12	0.33	0.49	1.02	-	-	0.77	.14	0.91	0.88	1.90
26	0.64	0.97	-	-	0.17	.16	0.33	0.40	0.98	-	-	0.83	.08	0.91	0.88	0.95
27	0.57	1.16	-	-	0.30	.29	0.59	0.63	0.95	-	-	0.84	.08	0.92	0.88	0.95
28	0.89	1.24	-	-	0.21	.14	0.35	0.37	0.94	-		0.84	.08	0.92	0.88	0.95
29	0.92	1.22	-		0.18	.12	0.30	0.33	0.95	-		0.88	.04	0.92	0.88	0.95
30	0.77	1.20	-	-	0.24	.19	0.43	0.33	0.81	-	-	0.85	.06	0.91	0.88	0.95
31	0.88	1.23	-	-	0.25	.10	0.35	0.34	0.89	-	-	0.81	.09	0.90	0.88	1.00

TABLE 3.2: DISINFECTION PROFILE FOR BRITANNIA/JULY 1985

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	1.46	1.84	-	-	0.12	.26	0.38	0.33	0.94	-	-	0.78	.21	0.99	0.87	1.00
2	1.38	1.80	-	-	0.30	.12	0.42	0.36	0.82	-	-	0.70	.18	0.88	0.87	1.00
3	1.30	1.75	-	-	0.26	.19	0.45	0.33	0.79	-	-	0.65	.26	0.91	0.87	1.00
4	1.22	1.80	-	..	0.32	.26	0.58	0.43	0.77	-		0.75	.17	0.92	0.87	1.00
5	1.14	1.80	-	-	0.26	.40	0.66	0.68	0.94	-	-	0.77	.15	0.92	0.87	NS
6	1.34	1.82	-	-	0.28	.20	0.48	0.46	0.86	-	-	0.71	.17	0.88	0.87	0.95
7	1.27	1.77	-	-	0.29	.21	0.50	0.55	0.90	-	-	0.66	.19	0.85	0.87	0.95
8	1.24	1.74	-	-	0.24	.26	0.50	0.49	0.87	-	-	0.72	.16	0.88	0.87	0.95
9	1.22	1.75	-	-	0.11	.42	0.53	0.53	0.87	-	-	0.81	.06	0.87	0.87	0.90
10	1.31	1.78	-	-	0.33	.14	0.47	0.34	0.87	-	-	0.75	.25	1.00	0.87	0.95
11	0.97	1.77	-	-	0.52	.28	0.80	0.66	0.81	-	-	0.75	.20	0.95	0.87	0.95
12	1.33	1.75	-	-	0.20	.22	0.42	0.46	0.84	-	-	0.63	.17	0.80	0.87	0.95
13	1.02	1.72	-	-	0.50	.20	0.70	0.65	0.85	-	-	0.78	.12	0.90	0.87	0.90
14	1.14	1.79	-	-	0.44	.21	0.65	0.67	0.92	-	-	0.86	.04	0.90	0.87	0.85
15	1.27	1.78	-	-	0.31	.20	0.51	0.53	0.93	-	-	0.86	.05	0.91	0.87	0.90
16	1.05	1.81	-	-	0.63	.13	0.76	0.71	0.87	-	-	0.76	.16	0.92	0.87	0.90
17	1.22	1.76	-	-	0.28	.26	0.54	0.58	0.92	-	-	0.80	.08	0.88	0.87	0.90
18	1.19	1.78	-	-	0.36	.23	0.59	0.56	0.89	-	-	0.86	.06	0.92	0.87	0.95
19	1.36	1.87	-	-	0.09	.42	0.51	0.48	0.87	-	-	0.78	.12	0.90	0.87	0.90
20	1.16	1.70	-	-	0.28	.26	0.54	0.48	0.85	-	-	0.80	.11	0.91	0.87	0.90
21	1.33	1.95	-	-	0.34	.28	0.62	0.60	0.88	-	-	0.80	.10	0.90	0.87	NS
22	1.37	2.00	-	-	0.38	.25	0.63	0.51	0.77	-	-	0.73	.16	0.89	0.87	0.90
23	1.21	1.93	-	-	0.49	.23	0.72	0.71	0.88	-	-	0.78	.11	0.89	0.87	0.90
24	1.28	2.08	-	-	0.54	.26	0.80	0.80	0.90	-	-	0.64	.16	0.90	0.87	0.90
25	1.25	1.97	-	-	0.51	.21	0.72	0.67	0.85	-	-	0.72	.18	0.90	0.87	NS
26	1.07	1.85	-	-	0.50	.28	0.78	0.70	0.82	-	-	0.76	.14	0.90	0.87	0.95
27	1.14	2.02	-	-	0.60	.28	0.88	0.74	0.76	-	-	0.75	.15	0.90	0.87	0.95
28	1.25	1.97	-	-	0.46	.26	0.72	0.72	0.92	-	-	0.87	.05	0.92	0.87	0.95
29	1.28	1.99	-	-	0.56	.15	0.71	0.68	0.87	-	-	0.74	.16	0.90	0.87	0.95
30	1.30	1.96	-	-	0.40	.26	0.66	0.60	0.83	-	-	0.65	.24	0.89	0.87	0.90
31	1.33	1.98	-	-	0.45	.20	0.65	0.50	0.77	-	-	0.62	.30	0.92	0.87	0.95

TABLE 3.2: DISINFECTION PROFILE FOR BRITANNIA/OCTOBER 1985

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	1.19	1.78	-	-	0.31	.28	0.59	0.79	1.09	-	-	0.87	.02	0.89	0.87	0.95
2	1.23	1.90	-	-	0.41	.26	0.67	0.70	0.93	-	-	0.84	.06	0.90	0.87	1.00
3	1.10	1.85	-	-	0.46	.29	0.75	0.89	1.06	-	-	0.88	.04	0.92	0.87	1.00
4	1.10	1.77	-	-	0.52	.15	0.67	0.76	1.01	-	-	0.88	.04	0.92	0.87	1.00
5	1.04	1.80	-	-	0.51	.25	0.76	0.79	1.01	-	-	0.90	.08	0.98	0.87	1.00
6	1.11	1.80	-	-	0.16	.53	0.69	0.78	0.99	-	-	0.81	.09	0.90	0.87	0.95
7	1.20	1.80	-	-	0.33	.27	0.60	0.70	0.98	-	-	0.82	.06	0.88	0.87	0.90
8	0.99	1.72	-	-	0.21	.52	0.73	0.76	0.93	-	-	0.83	.07	0.90	0.87	0.95
9	1.15	1.82	-	-	0.44	.23	0.67	0.68	0.92	-	-	0.83	.08	0.91	0.87	0.90
10	1.06	1.78	-	-	0.46	.26	0.72	0.69	0.87	-	-	0.82	.08	0.90	0.87	0.95
11	1.17	1.84	-	-	0.44	.23	0.67	0.77	0.98	-	-	0.78	.10	0.88	0.87	0.95
12	1.08	1.69	-	-	0.38	.23	0.61	0.66	0.97	-	-	0.84	.08	0.92	0.87	0.95
13	1.32	1.90	-	-	0.32	.26	0.58	0.65	1.00	-	-	0.82	.11	0.93	0.87	0.90
14	1.10	1.67	-	-	0.28	.29	0.57	0.61	0.96	-	-	0.82	.10	0.92	0.87	0.95
15	1.13	1.82	-	-	0.41	.28	0.69	0.60	0.91	-	-	0.88	.12	1.00	0.87	0.95
16	0.97	1.72	-	-	0.38	.37	0.75	0.77	0.93	-	-	0.77	.14	0.91	0.87	0.95
17	0.97	1.68	-	-	0.51	.20	0.71	0.61	0.90	-	-	0.93	.07	1.00	0.87	0.95
18	1.25	1.73	-	-	-	-	0.48	0.49	0.91	-	-	0.77	.13	0.90	0.87	0.95
19	1.05	1.69	-	-	0.41	.23	0.64	0.56	0.86	-	-	0.88	.06	0.94	0.87	1.00
20	1.13	1.73	-	-	0.33	.27	0.60	0.65	0.95	-	-	0.87	.03	0.90	0.87	1.00
21	1.01	1.69	-	-	0.46	.22	0.68	0.68	0.90	-	-	0.79	.11	0.90	0.87	1.00
22	1.14	1.80	-	-	0.44	.22	0.66	0.74	1.00	-	-	0.87	.05	0.92	0.87	1.00
23	1.05	1.70	-	-	0.42	.23	0.65	0.74	0.86	-	-	0.89	.05	0.94	0.87	1.00
24	1.25	1.74	-	-	0.29	.20	0.49	0.38	0.79	-	-	0.73	.17	0.90	0.87	1.00
25	1.10	1.76	-	-	0.38	.28	0.66	0.58	0.80	-	-	0.78	.10	0.88	0.87	1.00
26	1.18	1.69	-	-	0.31	.20	0.51	0.51	0.91	-	-	0.79	.12	0.91	0.87	1.00
27	1.13	1.75	-	-	0.42	.20	0.62	0.65	0.92	-	-	0.80	.09	0.89	0.87	0.95
28	1.09	1.71	-	-	0.51	.11	0.62	0.67	0.95	-	-	0.81	.09	0.90	0.87	1.00
29	1.22	1.77	-		0.37	.18	0.55	0.62	0.99	-	-	0.81	.11	0.92	0.87	1.00
30	1.07	1.80	-	-	0.37	.36	0.73	0.73	0.92	-	-	0.90	.02	0.90	0.87	1.00
31	1.08	1.80	-	-	0.49	.23	0.72	0.73	0.94	-	-	0.83	.10	0.93	0.87	1.00

TABLE 3.3: DISINFECTION PROFILE FOR BRITANNIA/JANUARY 1984

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	0.61	1.46	-	-	0.52	.33	0.85	0.77	1.02	-	-	0.85	.25	1.10	0.80	NS
2	1.00	1.39	-	-	0.15	.24	0.39	0.29	0.85	-	-	0.77	.18	0.95	0.80	NS
3	0.89	1.38	-	-	0.17	.32	0.49	0.35	0.79	-	-	0.82	.11	0.93	0.80	1.00
4	0.95	1.32	-	-	0.19	.18	0.37	0.28	0.79	-	-	0.77	.11	0.88	0.79	1.00
5	0.97	1.32	-	-	0.16	.19	0.35	0.29	0.83	-	-	0.77	.12	0.89	0.80	0.90
6	1.02	1.40	-	-	0.15	.23	0.38	0.62	1.06	-	-	0.80	.02	0.82	0.79	0.90
7	1.10	1.34	-	-	0.12	.12	0.24	0.42	0.98	-	-	0.76	.04	0.80	0.79	0.95
8	0.90	1.24	-	-	0.14	.20	0.34	0.35	0.88	-	-	0.80	.07	0.87	0.80	0.90
9	0.91	1.29	-	-	0.20	.18	0.38	0.42	0.91	-	-	0.66	.21	0.87	0.70	0.95
10	0.95	1.27	-	-	0.11	.21	0.32	0.35	0.83	-	-	0.72	.08	0.80	0.80	1.00
11	0.69	1.34	-	-	0.20	.45	0.65	0.77	0.94	-	-	0.78	.04	0.82	0.80	1.00
12	0.81	1.21	-	-	0.22	.18	0.40	0.57	1.00	-	-	0.80	.03	0.83	0.80	1.00
13	0.77	1.24	-	-	0.23	.24	0.47	0.56	1.02	-	-	0.88	.05	0.93	0.80	0.95
14	0.87	1.36	-	-	0.17	.32	0.49	0.51	0.99	-	-	0.84	.13	0.97	0.80	1.00
15	0.79	1.35	-	-	0.22	.34	0.56	0.53	0.94	-	-	0.89	.08	0.97	0.80	0.95
16	0.81	1.31	-	-	0.21	.29	0.50	0.57	1.01	-	-	0.83	.11	0.94	0.80	0.90
17	0.56	'.15	-		0.18	.41	0.59	0.66	0.91	-	*	0.55	.29	0.84	0.80	0.90
18	0.59	0.85	-	-	0.15	.11	0.26	0.27	0.83	-	-	0.70	.12	0.82	0.80	0.95
19	0.70	0.91	-	-	0.10	.11	0.21	0.27	1.01	-	-	0.59	.36	0.95	0.80	1.00
20	0.72	0.92	-	-	0.09	.11	0.20	0.39	1.03	-	-	0.79	.05	0.84	0.80	1.00
21	0.69	0.91	-	-	0.07	.15	0.22	0.15	0.80	-	-	0.76	.11	0.87	0.81	1.00
22	0.69	0.90	-	-	0.07	.14	0.21	0.37	1.01	-	-	-	-	0.85	0.80	NS
23	0.56	0.83	-	-	-	-	0.27	0.33	0.95	-	-	0.65	.24	0.89	0.80	1.00
24	0.60	0.89	-	-	0.19	.10	0.29	0.40	1.02	-	-	0.81	.10	0.91	0.80	0.95
25	0.71	0.93	-	-	0.10	.12	0.22	0.40	1.08	-	-	0.83	.07	0.90	0.80	0.95
26	0.78	1.05	-	-	0.19	.08	0.27	0.38	0.96	-	-	0.82	.03	0.85	0.80	0.95
27	0.62	0.93	-	-	0.16	.15	0.31	0.36	0.94	-	-	0.75	.14	0.89	0.80	1.00
28	0.67	0.96	-	-	0.15	.14	0.29	0.34	1.04	-	-	0.85	.14	0.99	0.80	1.00
29	0.70	0.99	-	-	0.19	.10	0.29	0.34	1.00	-	-	0.65	.30	0.95	0.80	1.00
30	0.68	1.02	-	-	0.19	.15	0.34	0.40	1.05	-	-	0.60	.39	0.99	0.80	0.95
31	0.66	0.99	-	-	0.16	.17	0.33	0.46	1.00	-	-	0.63	.24	0.87	0.80	0.95

TABLE 3.3: DISINFECTION PROFILE FOR BRITANNIA/MAY 1984

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	0.72	0.99	-	-	0.05	.22	0.27	0.22	0.91	-	-	0.80	.16	0.96	0.88	1.05
2	0.70	1.00	-	-	0.09	.21	0.30	0.35	0.96	-	-	0.82	.09	0.91	0.88	1.05
3	0.71	1.04	-	-	0.10	.23	0.33	0.34	0.95	-	-	0.66	.28	0.94	0.88	1.00
4	0.80	1.00	-	-	0.07	.13	0.20	0.32	0.97	-	-	0.66	.19	0.85	0.88	1.00
5	0.73	1.00	-	-	0.14	.13	0.27	0.31	0.95	-	-	0.82	.09	0.91	0.88	1.00
6	0.73	1.04	-	-	0.12	.19	0.31	0.34	0.93	-	-	0.81	.09	0.90	0.88	0.95
7	0.74	1.03	-	-	0.18	.11	0.29	0.42	1.04	-	-	0.76	.15	0.91	0.88	1.00
8	0.79	1.00	-	-	0.08	.13	0.21	0.30	0.98	-	-	0.74	.15	0.89	0.88	1.00
9	0.71	0.99	-	-	0.10	.18	0.28	0.23	0.85	-	-	0.67	.23	0.90	0.88	0.95
10	0.76	1.00	-	-	0.08	.16	0.24	0.28	0.93	-	-	0.74	.15	0.89	0.88	0.95
11	0.77	1.04	-	-	0.07	.20	0.27	0.41	0.99	-	-	0.72	.13	0.85	0.86	0.95
12	0.76	1.02	-	-	0.07	.19	0.26	0.35	1.03	-	-	0.75	.19	0.94	0.86	1.00
13	0.79	1.05	-	-	0.14	.14	0.26	0.35	1.02	-	-	0.85	.08	0.93	0.86	1.00
14	0.76	0.99	-	-	0.06	.17	0.23	0.33	1.02	-	-	0.76	.16	0.92	0.86	1.00
15	0.71	1.02	.13	-	0.13	.18	0.31	0.38	0.99	.11	-	0.67	.25	0.92	0.86	1.05
16	0.73	1.00	-	-	0.14	.13	0.27	0.36	1.02	-	-	0.66	.27	0.93	0.86	1.05
17	0.74	1.00	-	-	0.08	.18	0.26	0.27	1.01	-	-	0.88	.12	1.00	0.86	1.00
18	0.65	0.97	-	-	0.16	.16	0.32	0.42	1.03	-	-	0.76	.17	0.93	0.86	1.05
19	0.83	1.07	-	-	0.13	.11	0.24	0.33	1.01	-	-	0.72	.20	0.92	0.86	1.00
20	0.78	1.01	-	-	0.02	.21	0.23	0.30	0.97	-	-	-	-	0.90	0.86	1.00
21	0.79	1.01	-	-	0.11	.11	0.22	0.34	1.02	-	-	0.72	.18	0.90	0.86	1.00
22	0.75	1.05	-	-	0.13	.17	0.30	0.39	0.99	-	-	0.82	.08	0.90	0.86	1.00
23	0.72	1.00	-	-	0.11	.17	0.28	0.41	1.00	-	-	0.81	.06	0.87	0.86	0.95
24	0.70	0.98	-	-	0.14	.14	0.28	0.38	1.00	-	-	0.76	.14	0.90	0.86	0.95
25	0.79	1.01	-	-	-	-	0.22	0.33	1.01	-	-	-	-	0.90	0.86	0.95
26	0.84	1.04	-	-	0.08	.12	0.20	0.30	0.99	-	-	0.78	.11	0.89	0.86	1.00
27	0.99	1.17	-	-	0.05	.13	0.18	0.32	1.01	-	-	0.76	.11	0.87	0.86	1.10
28	0.89	1.20	-	-	0.14	.17	0.31	0.38	0.97	-	-	0.81	.09	0.90	0.86	1.10
29	0.87	1.20	-	-	0.14	.19	0.33	0.43	1.01	-	-	0.83	.08	0.91	0.86	1.10
30	0.95	1.25	-	-	0.12	.18	0.30	0.44	1.04	-	-	0.86	.04	0.90	0.86	NS
31	0.86	1.20	-	-	0.18	.16	0.34	0.48	1.05	-		0.72	.19	0.91	0.16	0.15

TABLE 3.3: DISINFECTION PROFILE FOR BRITANNIA/JULY 1984

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	1.46	1.97	-	-	-	-	0.51	0.61	1.01	-	-	0.70	.21	0.91	0.85	NS
2	1.32	1.97	-	-	0.34	.31	0.65	0.80	1.05	-	-	0.80	.10	0.90	0.85	1.00
3	1.02	1.97	-	-	0.62	.33	0.95	1.36	1.01	-	-	0.51	.09	0.60	0.85	1.00
4	1.27	1.97	-	-	0.42	.28	0.70	1.03	1.13	-	-	0.65	.15	0.80	0.85	1.05
5	1.37	1.96	-	-	0.17	.42	0.59	0.77	1.04	-	-	0.65	.21	0.86	0.85	1.05
6	1.44	2.03	-	-	0.15	.44	0.59	1.00	1.20	-	-	0.70	.09	0.79	0.85	1.00
7	1.29	1.99	-	-	0.23	.47	0.70	0.91	1.21	-	-	0.81	.19	1.00	0.85	1.05
8	1.28	2.03	-	-	0.40	.35	0.75	0.91	1.06	-	-	0.82	.08	0.90	0.85	1.00
9	1.37	2.02	-	-	0.26	.39	0.65	0.81	1.07	-	-	0.72	.19	0.91	0.85	0.95
10	1.21	2.00	0.37	-	0.39	.40	0.79	0.91	1.01	-	-	0.75	.14	0.89	0.85	1.00
11	1.43	1.97	-	-	0.25	.29	0.54	0.84	1.17	-	-	0.75	.12	0.87	0.85	1.00
12	1.33	1.98	-	-	0.38	.27	0.65	0.89	1.12	-	-	0.80	.08	0.88	0.85	1.00
13	1.27	2.00	-	-	0.36	.37	0.73	0.94	1.04	-	-	0.76	.07	0.83	0.85	1.00
14	1.35	2.03	-	-	0.36	.32	0.68	0.86	1.07	-	-	0.78	.11	0.89	0.85	1.00
15	1.41	2.05	-	-	0.32	.32	0.64	0.81	1.05	-	-	0.80	.08	0.88	0.85	NS
16	1.45	2.08	-	-	0.33	.30	0.63	0.79	1.05	-	-	0.81	.08	0.89	0.85	1.05
17	1.25	2.02	-	-	0.32	.45	0.77	0.96	1.09	-	-	0.83	.07	0.90	0.85	1.05
18	1.35	2.01	-	-	0.46	.20	0.66	0.84	1.08	-	-	0.72	.18	0.90	0.85	NS
19	1.52	2.07	-		0.16	.34	0.50	0.74	1.10	-		0.77	.09	0.86	0.85	1.05
20	1.37	2.06	-	-	0.42	.27	0.69	0.92	1.12	-	-	0.75	.14	0.89	0.85	1.10
21	1.17	1.97	-	-	0.38	.42	0.80	1.10	1.13	-	-	0.70	.13	0.83	0.85	1.00
22	1.42	2.05	-	-	-	-	0.63	0.83	1.13	-	-	0.83	.10	0.93	0.85	1.00
23	1.41	1.99	-	-	0.32	.26	0.58	0.76	1.10	-	-	-	-	0.92	0.85	1.00
24	1.45	2.02	-	-	0.27	.30	0.57	0.71	1.07	-	-	0.85	.08	0.93	0.85	1.00
25	1.35	2.06	-	-	0.43	.28	0.71	0.92	1.14	-	-	0.85	.08	0.93	0.85	1.05
26	1.37	2.04	-	-	0.29	.38	0.67	0.90	1.12	-	-	0.80	.09	0.89	0.85	1.00
27	1.23	1.98	-	-	-	-	0.75	1.04	1.19	-	-	0.85	.05	0.90	0.85	1.00
28	1.30	2.13	-	-	0.60	.23	0.83	1.03	1.10	-	-	0.85	.05	0.90	0.85	1.00
29	1.39	2.06	-	-	0.35	.32	0.67	0.92	1.13	-	-	0.85	.03	0.88	0.85	1.05
30	1.42	2.05	-	-	0.37	.26	0.63	0.88	1.18	-	-	0.86	.07	0.93	0.85	1.05
31	1.38	2.00	-	-	0.35	.27	0.62	0.86	1.17	-	-	-	-	0.93	-	-

TABLE 3.3: DISINFECTION PROFILE FOR BRITANNIA/OCTOBER 1984

DATE	PRE CHLORINATION							POST-CHLORINATION							FLUORIDE	
	Cl_2		NH_3	SO_2	RESIDUAL Cl_2			Cl_2		NH_3	SO_2	RESIDUAL Cl_2				
	Dem.	Dos.			Free	Comb.	Total	Dem.	Dos.			Free	Comb.	Total	Dos.	Res.
1	1.43	2.08	-	-	0.51	.14	0.65	0.77	1.02	-	-	0.83	.07	0.90	0.85	1.15
2	1.30	2.06	-	-	0.58	.18	0.76	0.87	1.01	-	-	0.84	.06	0.90	0.85	1.20
3	1.32	1.99	-	-	0.53	.14	0.67	1.02	1.15	-	-	0.75	.05	0.80	0.85	1.15
4	1.48	2.10	-	-	0.52	.10	0.62	0.74	1.02	-	-	0.78	.12	0.90	0.85	1.10
5	1.26	1.93	-	-	0.42	.25	0.67	0.64	0.92	-	-	0.87	.08	0.95	0.85	1.05
6	1.34	2.08	-	-	0.49	.25	0.74	0.83	0.98	-	-	0.80	.09	0.89	0.85	1.05
7	1.29	2.01	-	-	0.51	.21	0.72	0.77	0.96	-	-	0.82	.09	1.91	0.85	NS
8	1.39	2.15	-	-	0.53	.23	0.76	0.84	1.03	-	-	0.85	.10	0.95	0.85	1.10
9	1.30	2.08	-	-	0.47	.31	0.78	0.92	1.05	-	-	0.80	.11	0.91	0.85	1.15
10	1.30	2.02	-	-	0.35	.37	0.72	0.83	1.05	-	-	0.82	.12	0.94	0.85	1.00
11	1.22	1.80	-	-	0.38	.20	0.58	0.64	0.94	-	-	0.82	.06	0.88	0.85	1.05
12	1.17	1.80	-	-	0.40	.23	0.63	0.59	1.02	-	-	0.97	.09	1.06	0.85	0.95
13	1.07	1.78	-	-	-	-	0.71	0.89	1.05	-	-	0.69	.18	0.87	0.85	1.00
14	1.14	1.78	-	-	0.44	.20	0.64	0.65	1.00	-	-	0.88	.11	0.99	0.85	1.10
15	1.24	1.76	-	-	0.28	.24	0.52	0.65	1.02	-	-	0.72	.17	0.89	0.85	1.10
16	1.18	1.81	-	-	0.32	.31	0.63	0.71	0.97	-	-	0.73	.16	0.89	0.85	1.10
17	1.30	1.82	-	-	0.31	.21	0.52	0.62	1.00	-	-	0.78	.12	0.90	0.85	1.05
18	1.21	1.83	-	-	0.26	.36	0.62	0.59	1.08	-	-	0.92	.19	1.11	0.85	1.00
19	1.11	1.81	-	-	0.35	.35	0.70	0.79	1.00	-	-	0.82	.09	0.91	0.85	1.10
20	1.24	1.77	-	-	0.29	.24	0.53	0.66	1.02	-	-	0.73	.16	0.89	0.85	1.10
21	1.30	1.78	-	-	0.23	.15	0.48	0.57	1.03	-	-	0.89	.05	0.94	0.85	1.00
22	1.19	1.90	-	-	0.37	.34	0.71	0.83	1.01	-	-	0.81	.08	0.89	0.85	NS
23	1.36	1.80	-	-	0.26	.18	0.44	0.61	1.04	-	-	0.68	.19	0.87	0.85	NS
24	1.24	1.81	-	-	0.31	.26	0.57	0.71	1.03	-	-	0.88	.01	0.89	0.85	NS
25	1.14	1.80	-	-	0.41	.25	0.66	0.79	1.03	-	-	0.77	.13	0.90	0.85	NS
26	0.96	1.86	-		0.72	.18	0.90	1.12	1.04	-		0.53	.29	0.82	0.86	NS
27	1.13	1.81	-	-	0.36	.32	0.68	0.82	1.05	-	-	0.82	.09	0.91	0.86	NS
28	1.17	1.79	-	-	0.34	.28	0.62	0.72	1.02	-	-	0.81	.11	0.92	0.86	NS
29	1.16	1.80	-	-	0.30	.34	0.64	0.78	1.05	-	-	0.85	.06	0.91	0.86	NS
30	1.15	1.81	0.18	-	0.31	.35	0.66	0.72	1.03	0.11	-	0.85	.12	0.97	0.86	NS
31	1.22	1.82	-	-	0.35	.25	0.60	0.75	1.04	-	-	0.82	.07	0.89	0.86	NS

Table 4.0

<u>Legend</u>

W	-	LESS THAN DETECTION LIMIT
T	-	LOW VALUE TENTATIVE
CRO	-	CALCULATED RESULT ONLY
NP	-	NO DATA: NO APPROPRIATE PROCEDURE AVAILABLE
A3C	-	APPROX. RESULT: TOTAL COUNT EXCEEDED 300 COL.
UCR	-	UNRELIABLE: COULD NOT CONFIRM
/SM	-	NO DATA: SAMPLE MISSING

TABLE 4.0: BRITANNIA WATER QUALITY-1987

GENERAL CHEMISTRY		1987 JAN	FEB	MAR	APR	MAY	JUNE	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
General Chemistry									
Alkalinity mg/L	R	28.100	25.500	33.200	27.500	25.500	-	0.2 mg/L	
	T	33.300	32.200	38.800	27.200	29.200	-		
Ammonium Total mg/L	R	.038	.080	.062	.026	.024	-	0.05 mg/L	
	T	.010	.032	.028	.006 T	.006 T	-		
Calcium mg/L	R	10.300	9.500	12.200	10.700	9.200	-	0.1 mg/L	
	T	21.100	20.800	23.500	18.200	20.600	-		
Chloride mg/L	R	2.000 T	2.500	3.500	2.000 T	2.000 T	-	0.2 mg/L	250 mg/L
	T	4.500	4.000	5.500	4.500	4.500	-		
Colour TCU	R	35.000	32.000	31.000	35.000	29.000	-	0.5 TCU	5 TCU
	T	4.500	4.000	2.500 T	3.000	3.000	-		
Conductivity umho/cm	R	86.400	79.200	102.70	82.600	81.900	-	0.01 umho/cm	
	T	153.00	143.00	165.00	138.00	147.00	-		
Field Chlorine (combined) mg/L	R	-	-	-	-	-	-	0.1 mg/L	
	T	.200	.250	.150	-	-	-		
Field Chlorine (free) mg/L	R	-	-	-	-	-	-	0.1 mg/L	
	T	1.400	.900	1.500	-	-	-		
Field Chlorine (total) mg/L	R	-	-	-	-	-	-	0.1 mg/L	
	T	1.600	1.150	1.650	-	-	-		
Field PH	R	7.300	6.900	7.300	-	-	-	0.2	
	T	8.100	8.300	7.840	-	-	-		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

GENERAL CHEMISTRY contd		1987 JAN	FEB	MAR	APR	MAY	JUNE	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Field Temperature °C	R	3.500	4.000	8.000	-	-	-		
	T	3.000	2.000	2.200	-	-	-		
Field Turbidity FTU	R	1.900	2.300	.300	-	-	-		1 FTU
	T	1.050	.460	.530	-	-	-		
Fluoride mg/L	R	.060	.050 T	.050 T	.060	.050 T	-	0.01 mg/L	2.4 mg/L
	T	.850	.800	.810	.870	.890			
Hardness mg/L	R	35.500	33.500	40.500	38.500	33.000	-	0.5 mg/L	
	T	63.000	62.000	69.000	56.500	62.000	-		
Magnesium mg/L	R	2.400	2.400	2.500	2.800	2.400	-	0.05 mg/L	
	T	2.550	2.400	2.500	2.600	2.700	-		
Nitrate mg/L	R	.205	.235	.265	.175	.185	-	0.05 mg/L	10 mg/L
	T	.200	.235	.250	.175	.180	-		as N
Nitrite mg/L	R	.008	.006	.006	.004 T	.012	-	0.005	1 mg/L
	T	.001 T	.004 T	.002 T	.001 W	.008	-	mg/L	as N
Nitrogen Total	R	.330	.260	.270	.300	.240	-	0.1 mg/L	0.15 mg/L
Kjeldahl mg/L	T	.160	.140	.120	.130	.090 T			
PH	R	7.580	7.450	7.760	7.770	7.710	-		
	T	8.610	8.120	8.440	7.820	8.400	-		
Phosphorus Filtered	R	.003	.004	.002	.003	.003	-	0.01 mg/L	
Reactive mg/L	T	.002 T	.006	.006	.006	.008	-		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

GENERAL CHEMISTRY contd			1987 JAN	FEB	MAR	APR	MAY	JUNE	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Phosphorus Total		R	.009 T	.007 T	.012	.015	.009 T	-	0.01 mg/L	
	mg/L	T	.003 T	.005 T	.015	.016	.008 T	-		
Sodium	mg/L	R	2.400	2.700	3.400	2.200	.200 W	-	0.1 mg/L	
		T	2.900	3.300	6.900	2.700	3.800			
Total Solids	mg/L	R	56.200CRO	70.400	70.800	71.000	53.200CRO	-	1 mg/L	
		T	99.60CRO	93.000CRO	107.00CRO	89.800CRO	95.600CRO	-		
Turbidity	FTU	R	3.100	2.700	2.600	2.700	1.69	-	0.01 FTU	1 FTU
		T	1.690	.800	.340	.230	.330			
<u>Metals</u>										
Aluminum	mg/L	R	.210	.200	.260	.170	.140	-	0.003 mg/L	
		T	.140	.130	.091	.057	.100	-		
Arsenic	mg/L	R	.001	.001	.001	.001	.001	-	0.001 mg/L	0.05 mg/L
		T	.001	.001	.001	.001	.001	-		
Barium	mg/L	R	.017	.016	.018	.017	.016	-	0.001 mg/L	1 mg/L
		T	.015	.015	.015	.018	.014			
Beryllium	mg/L	R	.001	.001	.001	.001	.001	-	0.001 mg/L	
		T	.001	.001	.001	.001	.001	-		
Boron	mg/L	R	.020	.020	.020	.010 W	.010 W	-	0.02 mg/L	5 mg/L
		T	.020	.020	.020	.010	.010 W	-		
Cadmium	*ug/L	R	.300	.300	.300	.300	.300	-	0.0003 mg/L	0.005 mg/L
		T	.300	.300	.300	.300	.300	-		

* (ug/L) are units used on other sheet

TABLE 4.0: BRITANNIA WATER QUALITY-1987

METALS contd			1987						DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			JAN	FEB	MAR	APR	MAY	JUNE		
Chromium	mg/L	R	.001	.001	.001	.001	.001	-	0.001	0.05 mg/L
		T	.001	.001	.001	.001	.001	-	mg/L	
Cobalt	mg/L	R	.001	.001	.001	.001	.001	-	0.001	
		T	.001	.001	.001	.001	.001	-	mg/L	
Copper	mg/L	R	.008	.008	.022	.013	.011	-	0.001	1 mg/L
		T	.001 W	.001 W	.001	.001	.001	-	mg/L	
Cyanide	mg/L	R	.001 W	.001 W	.001 W	.001 W	.001 W	-	0.001	0.2 mg/L
		T	.001 W	.001 W	.001 W	.001 W	.001 W	-	mg/L	
Iron	mg/L	R	.200	.200	.240	.200	.180	-	0.002	0.3 mg/L
		T	.012	.029	.094	.058	.020	-	mg/L	
Lead	mg/L	R	.003	.003	.005	.003	.003	-	0.003	0.05 mg/L
		T	.003	.003	.003	.003	.003	-	mg/L	
Manganese	mg/L	R	.009	.010	.011	.012	.011	-	0.001	0.05 mg/L
		T	.007	.012	.014	.023	.016	-	mg/L	
Holybdenum	mg/L	R	.001 W	.001 W	.001 W	.001 W	.001 W	-	0.001	
		T	.001 W	.001 W	.001 W	.001 W	.001 W	-	mg/L	
Mercury	ug/L	R	.010	.010	.020	.020	.020	-	0.01	1 ug/L
		T	.010	.010	.020	.020	.020	-	ug/L	
Nickel	mg/L	R	.002	.002	.002	.002	.002	-	0.002	
		T	.002	.002	.002	.002	.002	-	mg/L	

TABLE 4.0: BRITANNIA WATER QUALITY-1987

METALS contd			1987						DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			JAN	FEB	MAR	APR	MAY	JUNE		
Selenium	mg/L	R	.001	.001	.001	.001	.001	-	0.001 mg/L	0.01 mg/L
		T	.001	.001	.001	.001	.001	-		
Strontium	mg/L	R	.046	.044	.048	.046	.047	-	0.001 mg/L	
		T	.048	.063	.067	.063	.063	-		
Tin		R	.000NP	.000NP	.000NP	.000NP	.000NP	-		
(no units available)		T	.000NP	.000NP	.000NP	.000NP	.000NP	-		
Uranium	mg/L	R	.200	.100	.200	.080	.080	-	0.002 mg/L	.02 mg/L
		T	.200	.100	.200	.010	.010	-		
Vanadium	mg/L	R	.001 W	.001 W	.001 W	.001	.001 W	-	0.001 mg/L	
		T	.001	.001	.001	.001	.001	-		
Zinc	mg/L	R	.008	.003	.013	.003	.004	-	0.001 mg/L	5 mg/L
		T	.004	.003	.007	.011	.005	-		
<u>Purgeables</u>										
Benzene	ug/L	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	10 ug/L
		T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Bromoform	ug/L	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	350 ug/L
		T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Carbon		R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	3 ug/L
Tetrachloride	ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Chlorobenzene	ug/L	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ng/L	100-300 ng/L
		T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

PURGEABLES cont'd		1987 JAN	FEB	MAR	APR	MAY	JUNE	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Chlorodibromomethane	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	350 ug/L
ug/L	T	.000 W	.000 W	.000 W	2.000	.000 W	.000 W		
Chloroform ug/L	R	.000 W	.000 W	.000 W	2.000 T	.000 W	.000 W	1 ug/L	350 ug/L
	T	89.000	54.000	70.000	110.00	132.00	132.00		
1,2-Dichlorobenzene	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	400 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
1,3-Dichlorobenzene	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	400 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
1,4-Dichlorobenzene	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	400 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Dichlorobromomethane	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	350 ug/L
ug/L	T	2.000	1.000	1.000	2.000	1.700	3.200		
1,1-Dichloroethane	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
1,2-Dichloroethane	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	10 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
1,1-Dichloroethylene	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	.3 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
1,1,2-Dichloro-	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	
ethylene ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

PURGEABLES cont'd		1987 JAN	FEB	MAR	APR	MAY	JUNE	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Dichloromethane	R	-	-	-	.000 W	-	-	5 ug/L	40 ug/L
ug/L	T	-	-	-	.000 W	-	-		
1,2-Dichloropropane	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Ethylbenzene ug/L	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	1400 ug/L
	T	.000 W	.000 W	.000 W	.000 W	.000 W	.200 T		
Ethylene Dibromide	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
M-Xylene ug/L	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	620 ug/L
	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
O-Xylene ug/L	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	620 ug/L
	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
P-Xylene ug/L	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	620 ug/L
	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Tolune ug/L	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	100 ug/L
	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
1,1,2,2-Tetrachloroe-	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	1.7 ug/L
thane ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Tetrachloroethylene	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	10 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

PURGEABLES cont'd		1987						DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
		JAN	FEB	MAR	APR	MAY	JUNE		
1,1,1-Trichloroethane	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	1000 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
1,1,2-Trichloroethane	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	6 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Trichloroethylene	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	30 ug/L
ug/L	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
Total Trihalomethanes	R	.000 W	.000 W	.000 W	.200	.000 W	.000 W	3 ug/L	350 ug/L
ug/L	T	91.000	55.000	71.000	74.000	111.70	135.20		
Trifluorochlorotolune	R	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W	1 ug/L	
	T	.000 W	.000 W	.000 W	.000 W	.000 W	.000 W		
<u>Organochlorines</u>									
Aldrin ng/L	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	700 ng/L
	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
Alpha Bhc ng/L	R	1.000 W	1.000 W	4.000 W	2.000 W	-	-	1 ng/L	700 ng/L
	T	1.000 W	1.000 W	3.000 W	2.000 W	-	-		
Alpha Chlordane	R	2.000 W	2.000 W	2.000 W	2.000 W	-	-	2 ng/L	700 ng/L
ng/L	T	2.000 W	2.000 W	2.000 W	2.000 W	-	-		
Beta Bhc ng/L	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	300 ng/L
	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
Dieldrin ng/L	R	2.000 W	2.000 W	2.000 W	2.000 W	-	-	2 ng/L	700 ng/L
	T	2.000 W	2.000 W	2.000 W	2.000 W	-	-		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

ORGANOCHLORINES contd		1987 JAN	FEB	MAR	APR	MAY	JUNE	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Endrin ng/L	R	4.000 W	4.000 W	4.000 W	4.000 W	-	-	4 ng/L	200 ng/L
	T	4.000 W	4.000 W	4.000 W	4.000 W	-	-		
Gamma Chlordane ng/L	R	2.000 W	2.000 W	2.000 W	2.000 W	-	-	2 ng/L	700 ng/L
	T	2.000 W	2.000 W	2.000 W	2.000 W	-	-		
Heptachlor Epoxide	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	3000 ng/L
ng/L	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
Heptachlor ng/L	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	3000 ng/L
	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
Hexachlorobenzene	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
ug/L	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
Hexachlorobutadiene	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
ng/L	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
Hexachloroethane	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	19000 ng/L
ng/L	T	6.000 T	1.000 W	B.000 T	2.000 T	-	-		
Lindane ng/L	R	1.000 W	1.000 W	1.000 W	-	-	-	1 ng/L	4000 ng/L
	T	1.000 W	1.000 W	1.000 W	-	-			
Methoxychlor ng/L	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	100000 ng/L
	T	2.000 W	2.000 W	2.000 W	2.000 W	-	-		
Mirex ng/L	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	
	T	5.000 W	5.000 W	5.000 W	5.000 W				

TABLE 4.0: BRITANNIA WATER QUALITY-1987

ORGANOCHLORINES contd		1987						DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
		JAN	FEB	MAR	APR	MAY	JUNE		
Octachlorostyrene	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	
ng/L	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
O,P-DDT ng/L	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	30000 ng/L
	T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		
Oxychlodane ng/L	R	2.000 W	2.000 W	2.000 W	2.000 W	-	-	2 ng/L	
	T	2.000 W	2.000 W	2.000 W	2.000 W	-	-		
PCB Total ng/L	R	20.000 W	20.000 W	20.000 W	20.000 W	-	-	20 ng/L	3000 ng/L
	T	20.000 W	20.000 W	20.000 W	20.000 W	-	-		
Pentachlorobenzene	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	74000 ng/L
ng/L	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
P,P-DDD ng/L	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	
	T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		
P,P-DDE ng/L	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	
	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
P,P-DDT ng/L	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	
	T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		
1,2,3,4,-Tetrachloro-	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	
benzene ng/L	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
1,2,3,5-Tetrachloro-	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	
benzene ng/L	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

ORGANOCHLORINES contd		1987 JAN	FEB	MAR	APR	MAY	JUNE	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
1,2,4,5-Tetrachloro-	R	1.000 W	1.000 W	1.000 W	1.000 W	-	-	1 ng/L	38000 ng/L
benzene ng/L	T	1.000 W	1.000 W	1.000 W	1.000 W	-	-		
Thiodan I ng/L	R	2.000 W	2.000 W	2.000 W	2.000 W	-	-	2 ng/L	74000 ng/L
	T	2.000 W	2.000 W	2.000 W	2.000 W	-	-		
Thiodan II ng/L	R	4.000 W	4.000 W	4.000 W	4.000 W	-	-	4 ng/L	74000 ng/L
	T	4.000 W	4.000 W	4.000 W	4.000 W	-	-		
Thiodan Sulphate	R	4.000 W	4.000 W	4.000 W	4.000 W	-	-	4 ng/L	
ng/L	T	4.000 W	4.000 W	4.000 W	4.000 W	-	-		
Toxaphene ng/L	R	.000 NP	.000 NP	.000 NP	.000 NP	-	-		
(no units available)	T	.000 NP	.000 NP	.000 NP	.000 NP	-	-		
1,2,3-Trichloro-	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	10000 ng/L
benzene ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		
1,2,4-Trichloro-	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	15000 ng/L
benzene ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		
1,3,5-Trichloro-	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	10000 ng/L
benzene ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		
2,3,6-Trichloro-	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	
benzene ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		
2,4,5-Trichloro-	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	10000 ng/L
benzene ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

ORGANOCHLORINES contd			1987						DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			JAN	FEB	MAR	APR	MAY	JUNE		
2,6,A-Trichloro-toluene	ng/L	R	5.000 W	5.000 W	5.000 W	5.000 W	-	-	5 ng/L	
		T	5.000 W	5.000 W	5.000 W	5.000 W	-	-		
TRIAZINES										
Alachlor	ng/L	R	500.00 W	500.00 W	500.00 W	500.00 W	-	-		
		T	500.00 W	500.00 W	500.00 W	500.00 W	-	-		
Ametrine	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	-	-	50 ng/L	
		T	50.000 W	50.000 W	50.000 W	50.000 W	-	-		
Atratone	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	-	-		
		T	50.000 W	50.000 W	50.000 W	50.000 W	-	-		
Atrazine	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	-	-	50 ng/L	46000 ng/L
		T	50.000 W	50.000 W	50.000 W	50.000 W	-	-		
Bladex	ng/L	R	100.00 W	100.00 W	100.00 W	100.00 W	-	-	100 ng/L	10000 ng/L
		T	100.00 W	100.00 W	100.00 W	100.00 W	-	-		
Metrolachlor	ng/L	R	500.00 W	500.00 W	500.00 W	500.00 W	-	-		
		T	500.00 W	500.00 W	500.00 W	500.00 W	-	-		
Prometone	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	-	-	50 ng/L	
		T	50.000 W	50.000 W	50.000 W	50.000 W	-	-		
Prometryne	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	-	-	50 ng/L	1000 ng/L
		T	50.000 W	50.000 W	50.000 W	50.000 W	-	-		
Propazine	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	-	-	50 ng/L	
		T	50.000 W	50.000 W	50.000 W	50.000 W	-	-		

TABLE 4.0: BRITANNIA WATER QUALITY-1987

TRIZINES contd			1987						DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			JAN	FEB	MAR	APR	MAY	JUNE		
Sencor	ng/L	R	100.00 W	100.00 W	100.00 W	100.00 W	-	-	100 ng/L	
		T	100.00 W	100.00 W	100.00 W	100.00 W	-	-		
Simazine	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	-	-	50 ng/L	10000 ng/L
		T	100.00 W	100.00 W	100.00 W	100.00 W	-	-		
BACTERIA										
RAW WATER:										
Total Coliform MF count/100 mL		R	176.00A3C	138.00A3C	100.00A3C	53.000A3C	100.00A3C	30.000A3C		
Total Coliform BDGD count/mL		R	242.00	8000.0	6900.0	560.00	1500.0	2400.0		
Fecal Coliform MF count/100 mL		R	24.000	26.000	6.000	15.000	10.000	7.000	0	0/0.1 mL
Standard Plate Count MF count/100 mL		R	1080.0	1800.0	2400.0	113.00	85.000	2400.0	0	500
TREATED WATER										
Present/Absent Test		T	A	A	A	A	A	A		
Total Coliform Background MF count/100 mL		T	.000	.000	4.000	.000	.000	.000	0	OWDO Bacti
Standard Plate Count MF count/100 mL		T	.000	.000	.000	1.000	.000	3.000		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

GENERAL CHEMISTRY			1986 SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
<u>General Chemistry</u>								
Alkalinity	mg/L	R	34.100	30.500	24.100	27.600	0.2 mg/L	
		T	33.100	30.600	26.600	31.200		
Ammonium Total	mg/L	R	0.012	0.020	.006 T	.020	0.05 mg/L	
		T	0.008	0.014	.002 W	.006 T		
Calcium	mg/L	R	12.300	10.500	8.900	9.800	0.1 mg/L	
		T	20.500	20.200	17.700	19.700		
Chloride	mg/L	R	3.500	3.500 T	2.350	2.500	0.2 mg/L	250 mg/L
		T	6.500	6.000	5.350	5.500		
Colour	TCU	R	31.500	38.000	38.500	36.000	0.5 TCU	5 TCU
		T	2.500	3.000	5.000	4.500		
Conductivity	umho/ cm	R	95.400	91.500	81.600	87.600	0.01 UMHO/ CM	
		T	153.00	154.00	139.00	149.00		
Field Chlorine (combined)	mg/L	R	-	-	-	-	0.1 mg/L	
		T	.100	.100	.100	.100		
Field Chlorine (Free)	mg/L	R	-	-	-	-	0.1 mg/L	
		T	.100	.100	.100	.100		
Field Chlorine (Total)	mg/L	R	-	-	-	-	0.1 mg/L	
		T	1.300	1.700	1.700	1.650		
Field PH		R	7.400	7.300	-	7.300	0.2	
		T	8.400	7.500	-	7.900		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

GENERAL CHEMISTRY contd			1986 SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Field Temperature	°C	R	17.000	12.800	5.700	3.600		
		T	16.000	11.800	3.600	2.000		
Field Turbidity	FTU	R	1.500	1.300	1.500	1.700		1 FTU
		T	3.100	.270	.180	.470		
Fluoride	mg/L	R	.000AD	.070	.050 T	.070	0.01 mg/L	2.4 mg/L
		T	.000AD	.850	.850	.840		
Hardness	mg/L	R	40.500	37.000	31.500	34.000	0.5 mg/L	
		T	62.500	61.000	54.000	59.500		
Magnesium	mg/L	R	2.400	2.600	2.250	2.300	0.05 mg/L	
		T	2.700	2.550	2.350	2.550		
Nitrate	mg/L	R	.220	.195	.355	.265	0.05 mg/L	10 mg/L
		T	.165	.210	.355	.250		as N
Nitrite	mg/L	R	.006	.005	.004 T	.013	0.005 mg/L	1 mg/L
		T	.003	.003 T	.001 W	.004 T		as N
Nitrogen Total	mg/L	R	.280	.230UCR	.240	.300	0.1 mg/L	0.15 mg/L
Kjeldahl		T	.130	.090UCR	.070 T	.180		
PH		R	7.830	7.770	7.800	7.810		
		T	8.100	7.860	7.920	7.910		
Phosphorus	mg/L	R	.003	.003	.002	.002	0.01 mg/L	
Filtered Reactive		T	.002 T	.005	.001 T	.001 T		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

GENERAL CHEMISTRY contd			1986				DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			SEPT	OCT	NOV	DEC		
Phosphorus Total	mg/L	R	.013	.012	.018	.007 T	0.01 mg/L	
		T	.003 T	.012	.013	.002 W		
Sodium	mg/L	R	3.100	2.700	2.190	3.000	0.1 mg/L	
		T	3.200	3.100	3.100	3.300		
Total Solids	mg/L	R	76.000	72.000	53.000CRO	64.800	1 mg/L	
		T	97.600CRO	100.000CRO	90.400CRO	89.800		
Turbidity FTU		R	.000AD	2.000	2.700	1.920	0.01 FTU	1 FTU
		T	.000AD	.510 T	.780	.200		
Metals								
Aluminum	mg/L	R	.093	.140	.190	.190	0.003 mg/L	
		T	.043	.160	.120	.083		
Arsenic	mg/L	R	.001	.001	.001	.001	0.001 mg/L	0.05 mg/L
		T	.001	.001	.001	.001		
Barium	mg/L	R	.017	.018	.081	.017	0.001 mg/L	1 mg/L
		T	.022	.018	.015	.016		
Beryllium	mg/L	R	.001	.001	.001	.001	0.02 mg/L	5 mg/L
		T	.001	.001	.001	.001		
Boron	mg/L	R	.020	.020	.020	.020	0.02 mg/L	5 mg/L
		T	.020	.020	.020	.020		
Cadium	mg/L	R	.400	.300	.300	.300	0.0003 mg/L	0.005 mg/L
		T	.400	.300	.300	.300		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

METALS contd			1986				DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			SEPT	OCT	NOV	DEC		
Chromium	mg/L	R	.001	.001	.001	.001	0.001 mg/L	0.05 mg/L
		T	.001	.001	.001	.001		
Cobalt	mg/L	R	.001	.001	.001	.001	0.001 mg/L	
		T	.001	.001	.001	.001		
Copper	mg/L	R	.012	.012	.010	.012	0.001 mg/L	1 mg/L
		T	.001	.001	.001	.001		
Cyanide	mg/L	R	.001 W	.001 W	.001 W	.001 W	0.001 mg/L	0.2 mg/L
		T	.001 W	.001 W	.001 W	.001 W		
Iron	mg/L	R	.130	.180	.210	.200	0.002 mg/L	0.3 mg/L
		T	.010	.160	.013	.010		
Lead	mg/L	R	.004	.003	.003	.003	0.003 mg/L	0.05 mg/L
		T	.004	.003	.003	.003		
Manganese	mg/L	R	.010	.013	.012	.011	0.001 mg/L	0.05 mg/L
		T	.005	.009	.008	.007		
Holybdenum	mg/L	R	.001 W	.001 W	.001 W	.001 W	0.001 mg/L	
		T	.001 W	.001 W	.001 W	.001 W		
Mercury	ug/L	R	.010	.010	.010	.020	0.01 ug/L	1 ug/L
		T	.010	.010	.010	.020		
Nickel	mg/L	R	.002	.002	.002	.002	0.002 mg/L	
		T	.002	.002	.002	.002		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

METALS contd			1986				DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			SEPT	OCT	NOV	DEC		
Selenium	mg/L	R	.001	.001	.001	.001	0.001 mg/L	0.01 mg/L
		T	.001	.001	.001	.001		
Strontium	mg/L	R	.050	.052	.045	.042	0.001 mg/L	
		T	.071	.065	.054	.049		
Tin		R	.000NP	.000NP	.000NP	.000NP		
(no units available)		T	.000NP	.000NP	.000NP	.000NP		
Uranium	mg/L	R	.110	.090	.100	.200 T	0.002 mg/L	.02 mg/L
		T	.080	.040	.050	.200 T		
Vanadium	mg/L	R	.001	.001 W	.001 W	.001	0.001 mg/L	
		T	.001	.001 W	.001	.001		
Zinc	mg/L	R	.014	.001 W	.020	.003	0.001 mg/L	5 mg/L
		T	.014	.001 W	.001	.002		
Purgeables								
Benzene	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	10 ug/L
		T	.000 W	.000 W	.000 W	.000 W		
Bromoform	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	350 ug/L
		T	.000 W	.000 W	.000 W	.000 W		
Carbon	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	3 ug/L
Tetrachloride		T	.000 W	.000 W	.000 W	.000 W		
Chlorobenzene	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ng/L	100-300 ng/L
		T	.000 W	.000 W	.000 W	.000 W		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

PURGEABLES contd			1986				DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			SEPT	OCT	NOV	DEC		
Chloro-	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	350 ug/L
dibromomethane		T	.000 W	.000 W	.000 W	.000 W		
Chloroform	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	350 ug/L
		T	203.00	145.00	145.00	120.00		
1,2	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	400 ug/L
Dichlorobenzene		T	.000 W	.000 W	.000 W	.000 W		
1,3	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	400 ug/L
Dichlorobenzene		T	.000 W	.000 W	.000 W	.000 W		
1,4	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	400 ug/L
Dichlorobenzene		T	.000 W	.000 W	.000 W	.000 W		
Dichlorobromo-	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	350 ug/L
methane		T	3.000	3.000	1.000	2.000		
1,1	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	
Dichloroethane		T	.000 W	.000 W	.000 W	.000 W		
1,2	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	10 ug/L
Dichloroethylene		T	.000 W	.000 W	.000 W	.000 W		
1,1	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	.3 ug/L
Dichloroethylene		T	.000 W	.000 W	.000 W	.000 W		
1,1,2	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	
Dichloroethylene		T	.000 W	.000 W	.000 W	.000 W		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

PURGEABLES contd			1986 SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Dichloromethane	ug/L	R	-	-	-	-	5 ug/L	40 ug/L
		T	-	-	-	-		
1,2 Dichloropropane	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	
		T	.000 W	.000 W	.000 W	.000 W		
Ethylbenzene	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	1400 ug/L
		T	.000 W	.000 W	.000 W	.000 W		
Ethylene Dibromide	ug/L	R	.000 W	.000 W	.000 W	.000 W		
		T	.000 W	.000 W	.000 W	.000 W		
M-Xylene	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	620 ug/L
		T	.000 W	.000 W	.000 W	.000 W		
O-Xylene	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	620 ug/L
		T	.000 W	.000 W	.000 W	.000 W		
P-Xylene	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	620 ug/L
		T	.000 W	.000 W	.000 W	.000 W		
Toluene	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	100 ug/L
		T	.000 W	.000 W	.000 W	.000 W		
1,1,2,2 Tetrachloroethane	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	1.7 ug/L
		T	.000 W	.000 W	.000 W	.000 W		
Tetrachloro-thylene	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	10 ug/L
		T	.000 W	.000 W	.000 W	.000 W		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

PURGEABLES contd			1986 SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
1,1,1	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	
Triochloroethane		T	.000 W	.000 W	.000 W	.000 W		
1,1,2	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	6 ug/L
Trichloroethane		T	.000 W	.000 W	.000 W	.000 W		
Trichloro-	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug.L	30 ug/L
Ethylene		T	.000 W	.000 W	.000 W	.000 W		
Total	ug/L	R	.000 W	.000 W	.000 W	.000 W	3 ug/L	350 ug/L
Trihalomethanes		T	206.00	148.00	146.00	122.00		
Trifluoro-	ug/L	R	.000 W	.000 W	.000 W	.000 W	1 ug/L	
chlorotoluene		T	.000 W	.000 W	.000 W	.000 W		
<u>Organochlorines</u>								
Aldrin	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	700 ng/L
		T	1.000 W	1.000 W	1.000 W	1.000 W		
Alpha BHC	ng/L	R	1.000 T	1.000 T	2.000 T	.000/SM	1 ng/L	700 ng/L
		T	2.000 T	1.000 T	2.000 T	2.000 T		
Alpha Chlordane	ng/L	R	2.000 W	2.000 W	2.000 W	.000/SM	2 ng/L	700 ng/L
		T	2.000 W	2.000 W	2.000 W	2.000 W		
Beta BHC	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	300 ng/L
		T	1.000 W	1.000 W	1.000 W	1.000 W		
Dieldrin	ng/L	R	2.000 W	2.000 W	2.000 W	.000/SM	2 ng/L	700 ng/L
		T	2.000 W	2.000 W	2.000 W	2.000 W		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

ORGANOCHLORINES contd			1986				DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			SEPT	OCT	NOV	DEC		
Endrin	ng/L	R	4.000 W	4.000 W	4.000 W	.000/SM	4 ng/L	200 ng/L
		T	4.000 W	4.000 W	4.000 W	4.000 W		
Gamma Chlordane	ng/L	R	2.000 W	2.000 W	2.000 W	.000/SM	2 ng/L	700 ng/L
		T	2.000 W	2.000 W	2.000 W	2.000 W		
Heptachlor Epoxide	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	3000 ng/L
		T	1.000 W	1.000 W	1.000 W	1.000 W		
Heptachlor	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	3000 ng/L
		T	1.000 W	1.000 W	1.000 W	1.000 W		
Hexachloro-benzene	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	10 ng/L
		T	1.000 W	1.000 W	1.000 W	1.000 W		
Hexachloro-butadiene	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM		
		T	1.000 W	1.000 W	1.000 W	1.000 W		
Hexachloroethane	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	19000 ng/L
		T	1.000 W	1.000 W	8.000 T	1.000 W		
Lindane	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	4000 ng/L
		T	1.000 W	1.000 W	8.000 T	1.000 W		
Methoxychlor	ng/L	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	
		T	5.000 W	5.000 W	5.000 W	5.000 W		
Mirex	ng/L	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	
		T	5.000 W	5.000 W	5.000 W	5.000 W		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

ORGANOCHLORINES contd			1986 SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Octachlorostyrene	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	
		T	1.000 W	1.000 W	1.000 W	1.000 W		
O,P-DDT	ng/L	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	30000 ng/L
		T	5.000 W	5.000 W	5.000 W	5.000 W		
Oxychlordane	ng/L	R	2.000 W	2.000 W	2.000 W	.000/SM	2 ng/L	
		T	2.000 W	2.000 W	2.000 W	2.000 W		
PCP Total	ng/L	R	20.000 W	20.000 W	20.000 W	.000/SM	20 ng/L	3000 ng/L
		T	20.000 W	20.000 W	20.000 W	20.000 W		
Pentachloro-	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	74000 ng/L
benzene		T	1.000 W	1.000 W	1.000 W	1.000 W		
P,P-DDD	ng/L	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	
		T	5.000 W	5.000 W	5.000 W	5.000 W		
P,P-DDE	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	
		T	1.000 W	1.000 W	8.000 T	1.000 W		
P,P-DDT	ng/L	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	
		T	5.000 W	5.000 W	5.000 T	5.000 W		
1,2,3,4	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	
Tetrachlorobenzene		T	1.000 W	1.000 W	1.000 W	1.000 W		
1,2,3,5	ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	
Tetrachlorobenzene		T	1.000 W	1.000 W	1.000 W	1.000 W		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

ORGANOCHLORINES contd		1986 SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
1,2,4,5- ng/L	R	1.000 W	1.000 W	1.000 W	.000/SM	1 ng/L	38000 ng/L
Tetrachlorobenzene	T	1.000 W	5.000 W	2.000 W	1.000 W		
Thiodan I ng/L	R	2.000 W	2.000 W	2.000 W	.000/SM	2 ng/L	74000 ng/L
	T	2.000 W	2.000 W	2.000 W	2.000 W		
Thiodan II ng/L	R	4.000 W	4.000 W	4.000 W	.000/SM	4 ng/L	74000 ng/L
	T	4.000 W	4.000 W	4.000 W	4.000 W		
Thiodan Sulphate	R	4.000 W	4.000 W	4.000 W	.000/SM	4 ng/L	
ng/L		4.000 W	4.000 W	4.000 W	4.000 W		
Toxaphene	R	.000NP	.000NP	.000NP	.000/SM		
(no units available)	T	.000NP	.000NP	.000NP	.000NP		
1,2,3-Trichlorobenzene	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	10000 ng/L
ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W		
1,2,4-Trichlorobenzene	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	15000 ng/L
ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W		
1,3,5-Trichlorobenzene	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	10000 ng/L
ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W		
2,3,6-Trichlorotoluene	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	
ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W		
2,4,5-Trichlorotoluene	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	10000 ng/L
ng/L	T	5.000 W	5.000 W	5.000 W	5.000 W		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

ORGANOCHLORINES contd			1986 SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
2,6,A-	ng/L	R	5.000 W	5.000 W	5.000 W	.000/SM	5 ng/L	
Trichlorotoluene		T	5.000 W	5.000 W	5.000 W	5.000 W		
Triazines								
Alachlor	ng/L	R	500.00 W	500.00 W	500.00 W	500.00 W		
		T	500.00 W	500.00 W	500.00 W	500.00 W		
Ametrine	ng/L	R	50.000 W	50.000 W	50.000 W	50.000/SM	50 ng/L	
		T	50.000 W	50.000 W	50.000 W	50.000 W		
Atratone	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W		
		T	50.000 W	200.000 T	50.000 W	50.000 W		
Atrazine	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	50 ng/L	46000 ng/L
		T	50.000 W	50.000 W	50.000 W	50.000 W		
Bladex	ng/L	R	100.00 W	100.00 W	100.00 W	100.00 W	100 ng/L	10000 ng/L
		T	100.00 W	330.00 T	100.00 W	100.00 W		
Metolachlor	ng/L	R	500.00 W	500.00 W	500.00 W	500.00 W		
		T	500.00 W	500.00 W	500.00 W	500.00 W		
Prometone	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	50 ng/L	
		T	50.000 W	100.00 T	50.000 W	50.000 W		
Prometryne	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	50 ng/L	1000 ng/L
		T	50.000 W	50.000 W	50.000 W	50.000 W		
Propazine	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	50 ng/L	
		T	50.000 W	50.000 W	50.000 W	50.000 W		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

TRIAZINES cont'd			1986 SEPT	OCT	NOV	DEC	DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
Sencor	ng/L	R	100.00 W	100.00 W	100.00 W	100.00 W	100 ng/L	
		T	100.00 W	100.00 W	100.00 W	100.00 W		
Simazine	ng/L	R	50.000 W	50.000 W	50.000 W	50.000 W	50 ng/L	10000 ng/L
		T	50.000 W	100.00 T	50.000 W	50.000 W		
<u>Special Pesticides</u>								
2,4,-D	ng/L	R	-	100.00 W	-	-	100 ng/L	100000 ng/L
		T	-	100.00 W	-	-		
2,4,-D Butyric Acid		R	-	200.00 W	-	-	200 ng/L	18000 ng/L
	ng/L	T	-	200.00 W	-	-		
Dicamba	ng/L	R	-	100.00 W	-	-	100 ng/L	87000 ng/L
		T	-	100.00 W	-	-		
Pentachlorophenol	ng/L	R	-	50.000 W	-	-	50 ng/L	10000 ng/L
		T	-	50.000 W	-	-		
Picloram	ng/L	R	-	.000/NP	-	-	100 ng/L	
		T	-	.000/NP	-	-		
2,4-D Propionic Acid		R	-	100.00 W	-	-	100 ng/L	
		T	-	100.00 W	-	-		
Silvex	ng/L	R	-	50.000 W	-	-	50 ng/L	10000 ng/L
		T	-	50.000 W	-	-		
2,4,5-T	ng/L	R	-	50.000 W	-	-	50 ng/L	
		T	-	50.000 W	-	-		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

SPECIAL PESTICIDES contd			1986				DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			SEPT	OCT	NOV	DEC		
2,3,4,5- Tetrachlorophenol	ng/L	R	-	50.000 W	-	-	500 ng/L	
		T	-	50.000 W	-	-		
2,3,5,6- Tetrachlorophenol	ng/L	R	-	50.000 W	-	-	50 ng/L	
		T	-	50.000 W	-	-		
2,3,4- Trichlorophenol	ng/L	R	-	100.00 W	-	-	100 ng/L	
		T	-	100.00 W	-	-		
2,4,5- Trichlorophenol	ng/L	R	-	50.000 W	-	-	50 ng/L	
		T	-	50.000 W	-	-		
2,4,6- Trichlorophenol	ng/L	R	-	50.000 W	-	-	50 ng/L	10000 ng/L
		T	-	50.000 W	-	-		
<u>Organophosphorus Pesticides</u>								
Diazinon	ng/L	R	-	20.000 W	-	-	50 ng/L	14000 ng/L
		T	-	20.000 W				
Dichlorovos	ng/L	R	-	20.000 W	-	-		
		T	-	20.000 W				
Dursban	ng/L	R	-	20.000 W	-	-		
		T	-	20.000 W	-	-		
Ethion	ng/L	R	-	20.000 W	-	-		
		T	-	20.000 W	-	-		
Guthion	ng/L	R	-	.000/NP	-	-		
		T	-	.000/NP	-	-		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

ORGANOPHOSPHORUS PESTICIDES contd			1986				DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
			SEPT	OCT	NOV	DEC		
Halathion	ng/L	R	-	20.000 W	-	-		
		T	-	20.000 W	-	-		
Methylparathion		R	-	20.000 W	-	-	50 ng/L	7000 ng/L
		T	-	20.000 W	-	-		
Methyltrithion	ng/L	R	-	20.00 W	-	-		
		T	-	20.00 W	-	-		
Mevinphos	ng/L	R	-	20.000 W	-	-		
		T	-	20.000 W	-	-		
Parathion	ng/L	R	-	20.000 W	-	-	50 ng/L	35000 ng/L
		T	-	20.000 W	-	-		
Phorbate	ng/L	R	-	20.000 W	-	-		
		T	-	20.000 W				
Reldan	ng/L	R	-	20.000 W	-	-		
		T	-	20.000 W				
Ronnel	ng/L	R	-	20.000 W	-	-		
		T	-	20.000 W	-	-		

TABLE 4.1: BRITANNIA WATER QUALITY-1986

BACTERIA		1986				DWSP DETECTION LIMIT	DRINKING WATER OBJ/ GUIDELINE
		SEPT	OCT	NOV	DEC		
Raw Water							
Total Coliform MF count/100mL	R	156.00A3C	300.00A3C	1700.0	63.000A3C		
Total Coliform BKGD count/100mL	R	8400.0	40000.0	2900.0	310.00		
Fecal Coliform MF count/100mL	R	114.00	78.000	102.00	11.000	0	0/0.1 mL
Standard Plant Count MF count/100mL	R	.000/AW	2400.0	2400.0	2400.0	0	500
Treated Water							
Present/Absent Test	T	A	A	A	A		
Total Coliform Back-Ground MF count/100mL	T	.000	.000	.000	.000		
Fecal Coliform FM count/100mL	T	-	-	-	-		
Standard Plate Count MF count/100mL	T	.000/AW	3.000	.000	1.000		

TABLE 5.0: ALGAE COUNT FOR BRITANNIA
(Raw Water)

MONTH	COUNT (ASU)			
	1986	1985	1984	1983
JAN	20	10	37	27
FEB	32	5	26	57
MAR	6	31	54	38
APR	ND	26	30	ND
MAY	ND	102	56	253
JUN	63	108	202 (1)	64
JUL	64	109	ND	80
AUG	ND	18	37	38
SEP	39	18	27	41
OCT	33	32	175	71
NOV	41	87	58	77
DEC	15	ND	33	111

(1) One intact Astrionelle accounts for 86 ASU

ND - No data

TABLE 6.0: BACTERIOLOGICAL TESTING (1986) BRITANNIA

MONTH	R/T	TOTAL COLIFORM					FECAL COLIFORM				
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500
JAN	R	0	0	2	29	0	0	16	5	10	0
	T	31	0	0	0	0	31	0	0	0	0
*FEB	R	0	0	6	19	0	0	17	12	2	0
	T	25	0	0	0	0	0	0	0	0	0
MAR	R	0	0	11	19	0	0	26	4	0	0
	T	30	0	0	0	0	30	0	0	0	0
APR	R	0	0	20	10	0	0	26	3	1	0
	T	30	0	0	0	0	30	0	0	0	0
MAY	R	0	0	23	8	0	0	18	4	9	0
	T	31	0	0	0	0	31	0	0	0	0
*JUN	R	0	1	26	2	0	0	19	3	7	0
	T	29	0	0	0	0	29	0	0	0	0
JUL	R	0	0	29	2	0	0	9	7	15	0
	T	31	0	0	0	0	31	0	0	0	0
AUG	R	0	0	17	14	0	0	3	2	26	0
	T	31	0	0	0	0	31	0	0	0	0
SEP	R	0	0	6	34	0	0	0	1	29	0
	T	30	0	0	0	0	30	0	0	0	0
*OCT	R	0	0	0	30	0	0	0	1	29	0
	T	30	0	0	0	0	30	0	0	0	0
*NOV	R	0	0	0	30	0	0	0	0	30	0
	T	30	0	0	0	0	30	0	0	0	0
DEC	R	0	0	0	31	0	0	0	0	31	0
	T	31	0	0	0	0	31	0	0	0	0

R = Raw; T = Treated; * = Samples Missing
All results are for 100 ml samples

TABLE 6.1: BACTERIOLOGICAL TESTING (1985) BRITANNIA

MONTH	R/T	TOTAL COLIFORM					FECAL COLIFORM				
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500
	R	0	0	0	31	0	0	1	0	30	0
JAN	T	31	0	0	0	0	31	0	0	0	0
	R	0	0	0	28	0	0	1	1	26	0
FEB	T	28	0	0	0	0	28	0	0	0	0
	R	0	0	2	28	0	0	7	2	21	0
*MAR	T	30	0	0	0	0	30	0	0	0	0
	R	0	0	16	14	0	0	11	4	15	0
APR	T	30	0	0	0	0	30	0	0	0	0
	R	0	0	31	0	0	0	20	8	3	0
MAY	T	31	0	0	0	0	31	0	0	0	0
	R	0	0	24	6	0	0	5	9	16	0
JUN	T	30	0	0	0	0	30	0	0	0	0
	R	0	0	31	0	0	0	5	6	20	0
JUL	T	31	0	0	0	0	31	0	0	0	0
	R	0	0	10	21	0	0	1	0	30	0
AUG	T	31	0	0	0	0	31	0	0	0	0
	R	0	0	4	26	0	0	3	0	27	0
SEP	T	30	0	0	0	0	30	0	0	0	0
	R	0	0	0	30	0	0	1	0	29	0
*OCT	T	30	0	0	0	0	30	0	0	0	0
	R	0	0	0	30	0	0	0	0	30	0
NOV	T	30	0	0	0	0	30	0	0	0	0
	R	0	0	9	20	0	0	5	4	20	0
*DEC	T	29	0	0	0	0	29	0	0	0	0

R = Raw; T = Treated; * = Samples Missing
All results are for 100 ml samples

TABLE 6.2: BACTERIOLOGICAL TESTING (1984) BRITANNIA

MONTH	R/T	TOTAL COLIFORM					FECAL COLIFORM				
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500
JAN	R	0	0	0	31	0	0	9	3	29	0
	T	31	0	0	0	0	31	0	0	0	0
FEB	R	0	0	0	29	0	0	4	2	23	0
	T	29	0	0	0	0	29	0	0	0	0
MAR	R	0	0	5	26	0	0	2	2	26	0
	T	31	0	0	0	0	31	0	0	0	0
APR	R	0	0	17	13	0	0	5	1	24	0
	T	30	0	0	0	0	30	0	0	0	0
MAY	R	0	0	29	1	0	0	15	7	9	0
	T	31	1	0	0	0	31	0	0	0	0
JUN	R	0	0	28	0	2	0	11	5	14	0
	T	30	0	0	0	0	30	0	0	0	0
JUL	R	0	0	31	0	0	0	12	7	12	0
	T	31	0	0	0	0	31	0	0	0	0
AUG	R	0	0	28	3	0	0	9	3	19	0
	T	31	0	0	0	0	31	0	0	0	0
SEP	R	0	0	5	25	0	0	7	2	21	0
	T	30	0	0	0	0	30	0	0	0	0
OCT	R	0	0	0	31	0	0	1	0	30	0
	T	31	0	0	0	0	31	0	0	0	0
NOV	R	0	0	0	30	0	0	1	0	29	0
	T	30	0	0	0	0	30	0	0	0	0
*DEC	R	0	0	1	28	0	0	0	1	28	0
	T	29	0	0	0	0	29	0	0	0	0

R = Raw; T = Treated; * = Samples Missing
All results are for 100 ml samples

TABLE 6.3: BACTERIOLOGICAL TESTING (1983) BRITANNIA

MONTH	R/T	TOTAL COLIFORM					FECAL COLIFORM				
		Absent	1-5	6-100	101-5000	>5000	Absent	1-5	6-10	11-500	>500
JAN	R	0	0	4	27	0	0	0	0	31	0
	T	31	0	0	0	0	31	0	0	0	0
FEB	R	0	0	1	27	0	0	0	0	28	0
	T	28	0	0	0	0	28	0	0	0	0
MAR	R	0	0	4	27	0	0	1	2	28	0
	T	31	0	0	0	0	31	0	0	0	0
APR	R	0	0	29	1	0	0	12	6	12	0
	T	30	0	0	0	0	30	0	0	0	0
*MAY	R	0	0	24	6	0	0	17	3	10	0
	T	30	0	0	0	0	30	0	0	0	0
*JUN	R	0	0	23	4	0	0	14	3	10	0
	T	27	0	0	0	0	27	0	0	0	0
JUL	R	0	0	22	8	0	0	11	3	17	0
	T	31	1	0	0	0	31	0	0	0	0
*AUG	R	0	0	13	17	0	0	2	2	26	0
	T	30	0	0	0	0	30	0	0	0	0
SEP	R	0	0	10	20	0	0	2	4	24	0
	T	30	0	0	0	0	30	0	0	0	0
OCT	R	0	0	1	30	0	0	0	1	30	0
	T	31	0	0	0	0	31	0	0	0	0
NOV	R	0	0	0	30	0	0	8	4	18	0
	T	30	0	0	0	0	30	0	0	0	0
DEC	R	0	0	2	29	0	0	7	3	21	0
	T	31	0	0	0	0	31	0	0	0	0

R = Raw; T = Treated; * = Samples Missing
All results are for 100 ml samples

APPENDIX D

EVALUATION OF THE EFFICIENCY OF THE SPIRAL FLOW FLOCCULATORS

TERMS OF REFERENCE

The water treatment plant optimization study for Britannia had an additional, site-specific request for an evaluation of the spiral flow flocculators (SFF). Factors to be assessed in the review included:

- exact flow through the SFF
- detail the root-mean-square velocity gradients at various flowrates, hence power input
- range of flowrates
- qualitative floc characteristics
- operational flexibility for tapered flocculation
- suitability for the raw water source
- overall efficiency for floc formation

Other factors which are relevant can also be included in the evaluation.

INTRODUCTION

The coagulation/flocculation process involves two distinct stages:

- destabilization of colloidal particles
- transport of destabilized particles to form flocculant solids which settle or filter readily

Both conventional and direct filtration plants require flocculation after the coagulation step. However, the degree of flocculation is dependent upon the requirement for sedimentation prior to filtration since dense, large floc particles settle well, but tend to clog filters quickly.

Flocculation involved the input of power into the liquid to aggregate the destabilized colloidal particles. There are

three principal power sources which have been used in flocculators:

- o gravitational
- o pneumatic
- o mechanical

Pneumatic and mechanical flocculators are relatively flexible in adjusting to changes in water quality and flowrates. However, gravitational flocculators tend to be inflexible in adapting to changed and are rarely used in large treatment plants (Ref. D-12). Nonetheless, a number of plants in Ontario utilize gravitational flocculators.

GENERAL THEORY OF FLOCCULATION

A mathematical description of the transport and aggregation step was first proposed by Von Smoluchowski (Ref. D-8).

Perikinetic flocculation results from interparticle contacts caused by Brownian motion (Ref. D-5). The differential equation describing perikinetic flocculation is:

$$\frac{dN}{dt} = \frac{-4\eta KTN^2}{3\mu} \qquad \text{(Egn. D-1)}$$

N = total concentration of particles at time, t

η = dimensionless collision efficiency factor

KT = Boltzman's constant times absolute temperature

μ = dynamic viscosity, $(N \cdot s)/m^2$

Perikinetic flocculation is second order with respect to particle concentration and is independent of particle size Orthokinetic flocculation describes interparticle contact resulting from bulk fluid motion. The original work of Von Smoluchowski (Ref. D-8) was adapted by Camp and Stein (Ref.

D-9) to account for the turbulent conditions found in water treatment. Their differential equation was of the form:

$$\frac{dN}{dt} = -\frac{2}{3}\eta G d^3 N^2 \qquad \text{(Egn. D-2)}$$

where;

G = root-mean-square velocity gradient, 1/s

d = particle diameter

The volume fraction of colloidal particles, Ω, characterizes the volume of colloidal particles in a unit volume of liquid (Ref. D-5). It is defined as:

$$\Omega = \frac{1}{6} \pi d_o{}^3 N_o \qquad \text{(Egn. D-3)}$$

where;

d_o = diameter of floc particles at time = 0

N_o = number of floc particles at time = 0

Substituting this into the orthokinetic flocculation equation and integrating produces:

$$\ln \frac{N}{No} = -\frac{4}{\pi}\eta \Omega G t \qquad \text{(Egn. D-4)}$$

Therefore, the number of particles remaining in solution is a function of the root-mean-square velocity gradient and flocculation time, Gt.

The problem of floc break-up was not accounted for by Camp and Stein (Ref. D-9). Argaman and Kaufman (REf. D-11) and LaMer and Healy (REf. D-6) examined complete flocculation models. Huck and Murphy (REf. D-11) tested all of the models on simulated mine wastewater using statistical

techniques and found none of the models, with and without floc break-up, were adequate. They presented a semi-empirical, second order model with a break-up term which adequately predicted the flocculation of simulated and actual mine wastewater.

While results are encouraging for simple systems, the complexity of natural waters prevents reliable application of flocculation models. Therefore, jar tests are utilized to determine flocculation properties and pilot-plants are constructed to determine the response of full-scale systems.

FACTORS AFFECTING COAGULATION AND FLOCCULATION

Coagulation and flocculation can be affected by a number of physical and chemical parameters, the magnitude of which may be determined through the use of jar tests.

Some physical factors which affect coagulation and flocculation are:

- rapid mix intensity and duration
- flocculation velocity gradient
- retention time
- flocculator type
- geometry of the flocculation basin
- temperature
- particle size
- surface concentration

Some chemical factors which influence coagulation and flocculation are:

- primary coagulant type
- primary coagulant dose
- coagulant aid type

- o coagulant aid dose
- o chemical feed concentration
- o sequence of dosing and time lag
- o final pH
- o alkalinity
- o sulphates and phosphates
- o organic matter
- o ionic strength
- o nature of colloidal particles

THEORETICAL BASIS OF GRAVITATIONAL FLOCCULATORS

Camp and Stein (Ref. D-9) developed the fundamental relationships between power dissipation by fluids and the resulting velocity gradients. The basis equation they derived was:

$$G = \left(\frac{P}{V \mu}\right)^{1/2} \qquad \text{(Egn. D-5)}$$

where:

G = root-mean-square velocity gradient, 1/s

P = power dissipation, W

μ = dynamic viscosity (N.s)/m²

V = volume of flocculation basin, m³

For gravitational flocculators such as baffled mixing channels or conduits, the power dissipation can be calculated from a knowledge of the flowrate and head loss from (Ref. D-5 and Ref. D-13):

$$P = \frac{Q \gamma h_f}{V} = \frac{\gamma h_f}{t} \qquad \text{(Egn. D-6)}$$

where:

Q = volumetric flowrate, m³/s

γ = specific weight of water, kN/m³

h_f = head loss, m
V = volume of flocculation tank, m³
t = mean hydraulic detention time

APPLICATION TO SPIRAL FLOW FLOCCULATORS

Camp (Ref. D-13) described the various types of flocculators which had been used in the water treatment industry. A variation of the baffled channel gravitational flocculator was the spiral flow flocculator. Originally, this type of tank was used for rapid mixing of the coagulant. Spiral flow flocculation consists of introducing a high velocity flow tangentially into the tank, square or circular, which produces spiral motion in the liquid. The value of P can be calculated from Equation D-6 if h_f is the velocity head at the tank inlet. The velocity head is defined as:

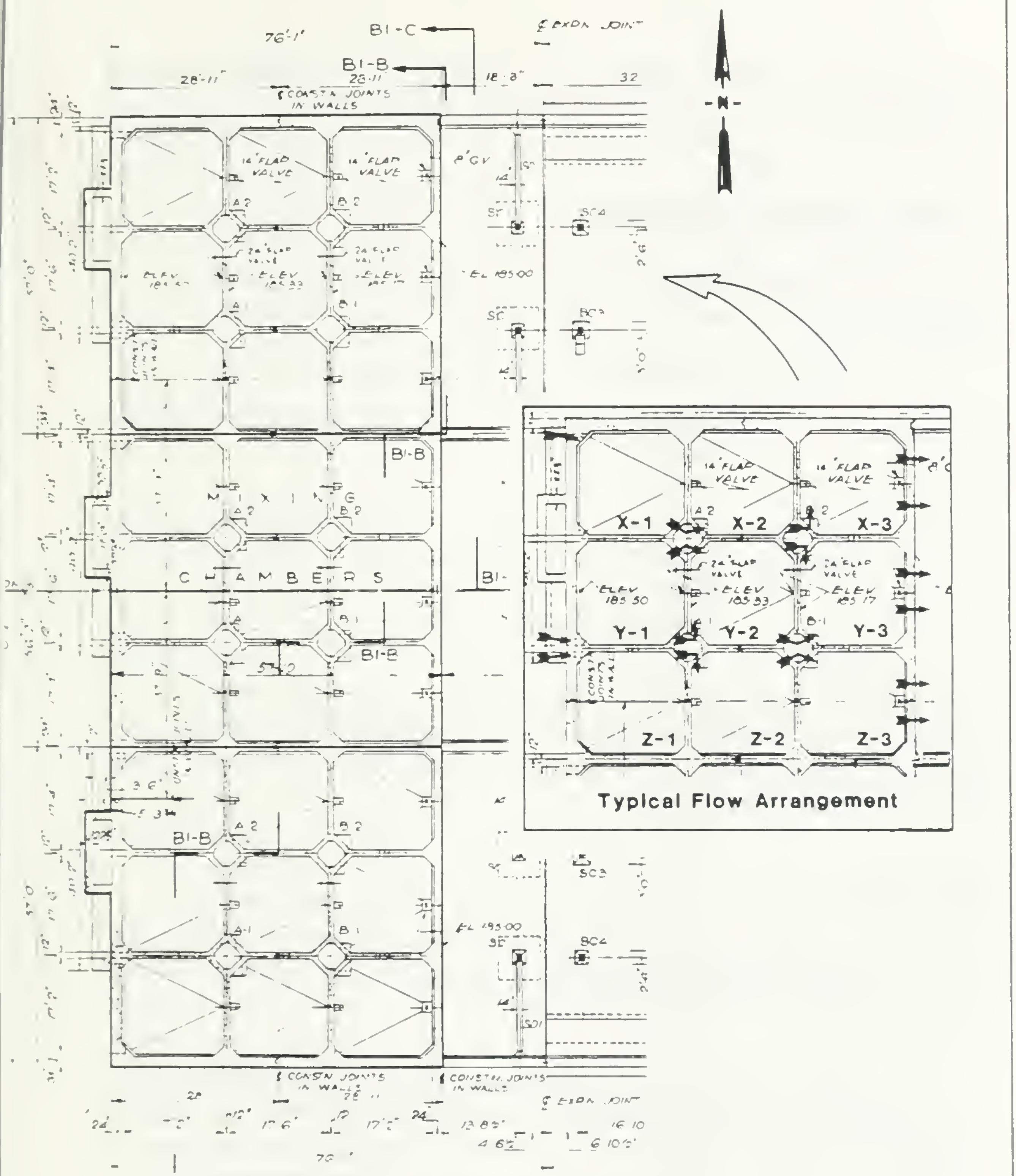
$$h_f = \frac{v^2}{2g} \qquad \text{(Eqn. D-7)}$$

where:
v = mean liquid velocity, m/s
g = gravity constant, m/s²

Figure D-1 is a schematic sketch of a series of three flocculation tanks such as found at Britannia Water Treatment Plant.

The foregoing has laid the theoretical foundation for calculating the root-mean-square velocity gradients from a knowledge of P. Substituting Equation D-6 into Equation E-5 results in the following (Ref. D-14):

$$G = \left(\frac{\gamma \, h_f}{\mu \, t}\right)^{\frac{1}{2}} \qquad \text{(Eqn. D-8)}$$



Appendix Figure D-1
SPIRAL FLOW FLOCCULATORS
USED AT BRITANNIA WATER TREATMENT PLANT

CANVIRO

This fundamental relationship will be used to evaluate the factors affecting the performance of a spiral flow flocculator.

FACTORS AFFECTING PERFORMANCE

Equation D-8 demonstrates that the root-mean-square velocity gradient in a gravitational flocculator is a function of:

- physical characteristics of the water;
  - density
  - viscosity

- hydraulic characteristics of the flocculation basin;
  - head loss
  - detention time

The physical characteristics of the water are significantly influenced by temperature and since a surface water source may have large seasonal variations in temperature, this factor must be considered.

The hydraulic design of the flocculation basin influences the liquid detention time and the head loss. The potential for short-circuiting in the flocculation tank needs to be evaluated since increased velocity gradients may result leading to poor floc characteristics.

An additional factor to consider when tanks are operated in series, is the effect of inter-tank transfer on the integrity of the floc particles. Also, changes in flowrate will alter the head loss at the tank inlet and subsequently change the root-mean-square velocity gradient which will in turn, alter the rate of floc formation.

Temperature

Examination of Equation D-8 reveals that G is a root inverse function of liquid viscosity and root function of the specific weight. The raw water temperature range at Britannia Water Treatment Plant typically is in the order of 0.2 to 24°C for winter and summer, respectively. Therefore, between the seasonal extremes in water temperature, the G can be decreased by 29% in the winter from water temperature alone. If flowrates cannot be increased, the performance of the flocculator cannot be altered. The problem can be further exacerbated in the winter since this season typically has the lowest water flow in the plant.

Short-circuiting

Hydraulic short-circuiting refers to residence time distributions which are not ideal. The impact of short-circuiting is that some particles are not flocculated and escape. A common method for alleviating the problems of short-circuiting is to build flocculation tanks in series (Ref. D-13). However, spiral flow flocculators in series have a serious disadvantage in that the transfer from tank-to-tank involves high velocity travel through the interconnecting pipe, potentially resulting in floc break-up.

Head Loss

The dissipation of the velocity head in the flocculator provides the energy necessary for fluid motion. G is a root function of the velocity head loss (Eqn. D-7). Between the peak summer flows and the minimum winter flows, 186 ML/d and 63 ML/d in 1986, respectively, the velocity head decreases by 86%. This translates into a decrease in G of 66% as a result of flow variation alone. The hydraulic reduction of G combined with the temperature induced decrease in G can cause extreme seasonal variation in the performance of the flocculators.

ASSESSMENT OF THE EFFICIENCY OF THE SPIRAL FLOW FLOCCULATORS AT BRITANNIA

Exact Flow

The flow through the individual flocculator streams is not measured at Britannia. Since the flocculators are arranged as 3 paralleled sets of 3, each set containing 3 tanks in series, it is assumed that the flow is equally divided into 9 equal streams. Table D-1 summarized the physical and hydraulic characteristics of a typical set of 9 flocculators (Figure D-1). The total volume of the 27 tanks is 5175 m^3.

For purposes of evaluating the performance of these flocculators, certain flowrates from 1986 have been selected as representative of the extremes of operation at the Britannia Water Treatment Plant. These are summarized in the following table.

1986 Flowrates Used in Evaluation
of Spiral Flow Flocculators in Table D-1

January 1986

Q_{min} = 71 ML/d
Q_{max} = 151 ML/d

July 1986

Q_{min} = 134 ML/d
Q_{max} = 186 ML/d.

VELOCITY GRADIENTS

The root-mean-square velocity gradient in a spiral flow flocculator can be determined from Equations D-7 and D-8. The G values have been calculated using the January and July 1986 flow data tabulated above. Table D-1 contains the calculated data for a typical group of 9 flocculation tanks. As can be seen, there is a significant reduction in the G value in January as a result of the cold water. In general, the G and Gt values calculated for Britannia are lower than those generally found in other spiral flow conditions do the G values fall within the range typical of conventional treatment plants using tapered flocculation (Ref. D-14).

The unique aspect of the centre series of flocculators (Y-1, Y-2, Y-3) is that they have two inlets rather than one as is typical of the outer series. The total inlet cross-sectional area is identical except that it occurs as two equal areas. There are two significant aspects resulting from this arrangement:

1. There is a higher frictional head loss associated with the two inlet structures, and

2. The root-mean-square velocity gradients will be higher than the adjacent, single-inlet tanks because two velocity heads are being dissipated rather than one.

There are no flow measurement devices in the flocculators, therefore the significance of the extra frictional head losses cannot be determined. Similarly, the three series of flocculators discharge into the same clarifier, therefore the effect of higher G values cannot be evaluated.

Table D-1
Summary of Spiral Flow Flocculator
Characteristics for a Typical Group
of Nine Flocculator Series

	x			y			z			Total
	1	2	3	1	2	3	1	2	3	
Volume, m^3	187	192	190	191	196	194	189	194	192	1725
Inlet cross-sectional area, m^2	0.165	0.465	0.542	0.165	0.233 0.233	0.271 0.271	0.165	0.465	0.542	
Detention time, s, at:										
Winter* min. Q	2040	2100	2080	2090	2140	2120	2070	2120	2100	
Winter max. Q	962	987	977	982	1010	998	965	998	987	
Summer** min. Q	1080	1110	1100	1110	1140	1120	1090	1120	1110	
Summer max. Q	781	804	793	797	818	810	789	810	804	
Root-mean-square velocity gradient, s^{-1} at:										
Winter* min. Q	6.6	2.3	2.0	6.5	3.2	2.8	6.6	2.3	2.0	
Winter max. Q	20	7.2	6.2	20	10	8.6	20	7.2	6.2	

Table D-1 (continued)
Summary of Spiral flow Flocculator
Characteristics for a Typical Group
of Nine Flocculator Series

	x			y			z			Total
	1	2	3	1	2	3	1	2	3	
Summer min. Q	24	8.3	7.1	23	12	1	24	8.3	7.1	
Summer max. Q	39	14	12	38	19	16	38	14	12	
Gt values at:										
Winter min. Q	13500	4830	4160	13600	6850	5940	13700	4880	4200	
Winter max. Q	19200	7110	6060	19600	10100	8580	19300	7190	6120	
Summer min. Q	25900	9210	7810	25500	13700	11200	26200	9300	7880	
Summer max. Q	30500	11300	9520	30300	15500	13000	30800	11300	9650	

* Winter water temperature 0.7°C
** Summer water temperature 24°C

Efficiency of Floc Formation Prior to Settling

The evidence provided in Appendix A, Table 2.1, for January and July 1986 support the hypothesis that the flocculators may be performing poorly during the winter months. The mean turbidity of the settled water in January was 1.4 NTU whereas the mean turbidity of the settled water in July was 0.8 NTU, 43% lower than in the winter. Also, if one compares raw water turbidity in January with the settled water turbidity, it is apparent that there is little practical difference. Whereas, in July, there is a significant difference between raw water turbidity and settled water turbidity. However, these observations may be confounded by degraded performance of the clarifiers since they are operating at the upper limit of acceptable overflow rates.

The MOE has had some concerns that the exit velocity from the flocculators is potentially causing floc break-up. However, as was discussed in Section C.3 (f), at 192 ML/d the exit velocity was 0.28 m/s. Kamanga (Ref. D-16) concluded that 0.3 m/s was a desirable velocity to prevent floc break-up.

Type of Floc Produced

The jar testing reported in Appendix B summarized the appearance of the floc in the jar tests and noted that they were similar to those observed in the flocculators. The jar tests were conducted in October of 1987. No information is available on the appearance of the floc particles in the winter.

Operational Flexibility

The flowrate and viscous properties of water determine the operating characteristics of gravitational flocculators. The concept of tapered flocculation has evolved from the necessity of preventing floc break-up as the floc particles grow. The typical range of G for flocculators used in conventional treatment is from 50 down to 10 L/s (REf. D-14). At peak summer flows, the Britannia flocculators lie within this range (Table D-1). However, under other conditions of flow and temperature, the flocculators generally have G values which are lower.

Total flocculation time in all seasons and at all flowrates falls within accepted guideline values (Ref. D-14 and D-15).

The flexibility of the system is limited to changes in flowrate. The proportion between tapered flocculation stages is fixed. Currently, flows through the set of three flocculation tanks (9 tanks) is not controllable. Therefore, the flocculator performance is a function of the random variation in flowrate and seasonal water temperature variations, generally resulting in Gt values lower than desirable.

Applicability to the Ottawa River Water Supply

From the critique of spiral flow flocculators, two conclusions can be drawn:

- the flocculators are sensitive to changes in water temperature

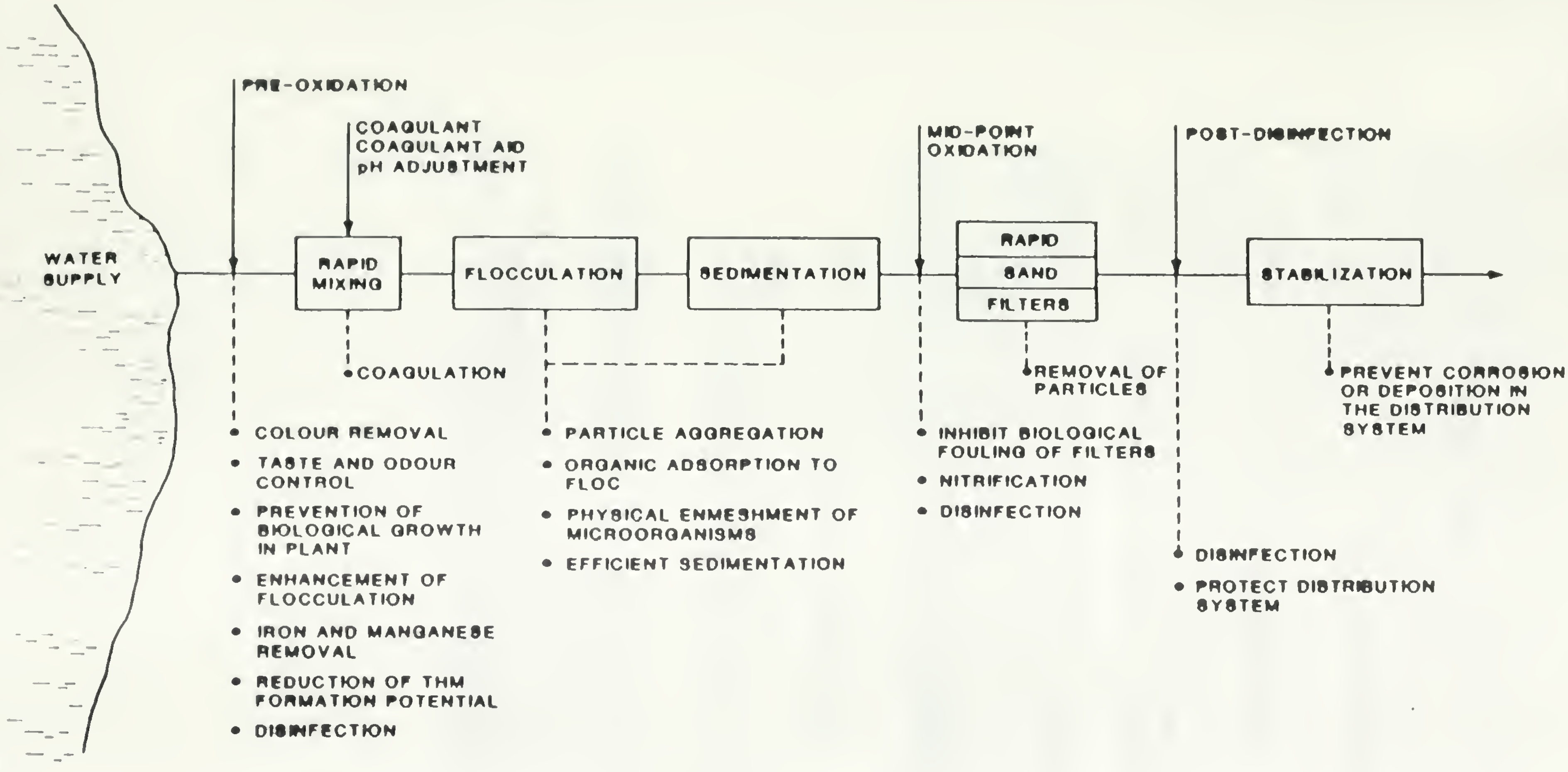
- the flocculators are sensitive to changes in flowrate

The multiple-barrier concept is fundamental to good water treatment practice. Figure D-2 illustrates conceptually a typical process flowsheet for treating a surface water supply. Flocculation is an integral part of the particle removal process. In addition, significant removals of soluble organic compounds and microorganisms also occur. Failure of the flocculation process results in the filters being challenged unnecessarily by contaminants. At Britannia, the historical record suggests that the filters have been able to consistently remove particles which have carried over from the clarifiers.

SUMMARY AND CONCLUSIONS

There is evidence that the flocculation and sedimentation processes do not achieve optimum performance during cold water conditions.

Therefore, it is recommended that during periods of low flow during the winter months, an evaluation of the removal from service of one set of flocculators be undertaken.



Appendix Figure D2

TYPICAL WATER TREATMENT PROCESSES FOR TREATING A SURFACE WATER SUPPLY

CANVIRO

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APPENDIX E

TERMS OF REFERENCE

Purpose

To review the present conditions and determine an optimum treatment strategy for contaminant removal at the plant, with emphasis on particulate materials and disinfection processes.

Work Tasks

1. Receive an information package from the MOE. Review the information provided and meet with the MOE staff, if required, to discuss the project.

2. Document the quality and quantity of raw and treated waters.

3. Define the present treatment processes and operating procedures. Prepare a progress report on Works Tasks 1-3 for the Project Committee.

4. Assess the methods of efficient particulate removal which would utilize the present major capital works of the plant. Evaluate the particulate removal efficiency and sensitivity of operation, assuming optimum performance of the plant.

5. Assess current disinfection practices and possible improvement methods.

6. Describe possible short and long-term process modifications to obtain optimum disinfection and contaminant removal.

7. Prepare a draft report for the project committee's review.

8. Prepare the final report.

1. RECEIVE AN INFORMATION PACKAGE FROM THE MOE. REVIEW THE INFORMATION PROVIDED AND MEET WITH THE MOE STAFF, IF REQUIRED, TO DISCUSS THE PROJECT.

Elements of Work

(a) Receive an information package from the MOE concerning the plant and the study. This package includes a general terms of reference, a general table of contents for organizing the study in a manner consistent with other plant reports, the WPOS reporting tables and a copy of Ontario Drinking Water Objectives.

(b) Review the information and prepare for a meeting to initiate the work on the project, including preparation of a schedule of manpower and staff committments.

(c) Meet with the MOE to discuss the available data, the terms of reference, and the project staff and work schedule. If a consultant is carrying out more that one study it may not be necessary to meet with the MOE at the start of each study.

2. DOCUMENT THE QUALITY AND QUANTITY OF RAW AND TREATED WATERS.

Elements of Work

(a) Prepare a monthly summary of maximum, minimum, and average flows for the last three consecutive years (Table 1.0). Address any discrepancies which exist between raw and treated flow rates.

(b) Based on the above, briefly review and tabulate for the last three years, the monthly maximum, minimum, and average per capita flow for the total population served by the plant (Table 1.1). Compare the plant data with typical per capita flows for the local region. Indicate major consumers who may influence the figures.

(c) Document the methods of measuring the raw and treated water flow rates.

(d) Summarize, for the last three consecutive years, where available, the raw and treated water; turbidity, colour, residual aluminum/iron, pH, temperature and treatment chemical dosages (other than disinfection and fluoridation). The summary should indicate the monthly daily average and maximum and minimum day (Table 2.0).

For the same three year period, tabulate also the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with particulate removal occurred (Tables 2). Document enough data to define and evaluate those problems.

Record other data, such as particulate counting, suspended solids, and algae counting (Table 5.0) which could reflect on particulate removal efficiency.

<u>Document the source and methods used in determining all information.</u>

A comparison should be made between the plant and outside laboratory information to ascertain the relative validity of the data. For plant data, emphasis should be given to plant laboratory tests rather than continuous process control instruments.

(e) Summarize for the last three consecutive years, where available, the disinfectant demand, dosages (including all disinfection related chemicals and residuals) for all application points as well as fluoridation dosage and residual. The summary should indicate the monthly daily average and maximum and minimum day (Table 3.0).

For the same three year period, tabulate (Tables 3) the daily average for the typical seasonal months of January, April, July and October as well as other months in which problems with chlorine residuals and/or positive bacterial tests identified in Table 6. Document enough data to define and evaluate those problems.

Document the methods of dosage evaluation and residual measurements, and establish the validity of the data provided.

(f) Prepare a summary, based on at least three years of data, of the raw and treated water quality testing data for physical, microbiological, radiological, and chemical water quality information (Table 4). Document as much data as is needed to show possible seasonal trends in water quality. Where possible, show corresponding sets of raw and treated water quality information.

Document the source and methods used in determining all water quality information and establish the validity of the data, comparing plant and outside laboratory data.

(g) Tabulate, for the last three consecutive years, the raw and treated water bacterial test information at the plant (Table 6).

Document the source and methods used for all data provided.

(h) Document the water sampling systems (source, pump, line-material and, size, vertical rise velocity sampling location) used in the plant (similar to DWSP Questionnaire in Appendix A).

(i) Prepare a summary of inplant testing including Test, Sampling Point, Testing Frequency, Reporting Frequency, Testing Instrumentation including calibration.

(j) Identify other water quality concerns, not related to particulate removal or disinfection, which should be considered as part of the assessment phase of this evaluation program.

3. DEFINE THE PRESENT TREATMENT PROCESSES AND OPERATING PROCEDURES. PREPARE A PROGRESS REPORT ON WORK TASKS 1-3 (8 COPIES), FOR THE PROJECT COMMITTEE.

Elements of Work

(a) Where drawings are available, assemble sufficient record drawings of a reduced size, to document the general site layout and the interrelationship of major plant components. If available, include a process and piping diagram (PAPD) of the plant operations.

(b) Prepare a simplified block schematic of all major plant components including chemical systems and indicating design parameters. Appendix B is an example of the required standard schematic.

(c) Prepare a photographic record of the plant facilities, illustrating all of the major plant components and chemical feed systems. The record should include approximately 30-40 coloured (9 cm x 12 cm) (or 10 cm x 15 cm) prints, suitably labelled. The progress and draft reports may include photocopies in lieu of the prints.

(d) Tabulate the design parameters for all the major plant components, with emphasis on the process operations, including chemical feeds. This information, as a minimum, must be consistent with the DWSP Questionnaire (Appendix A) and must be confirmed and verified by field observations. The design parameters should be evaluated at design, rated and actual operational flows.

(e) Prepare a summary of how the plant is operated, including chemical dosage control, such as jar testing information, filter backwashing procedures and initiation, and pumping and flow control.

(f) Document all reported and other apparent problems in plant operations and/or in the distribution system related to water quality. In addition list the health related parameters which exceed the Ontario Drinking Water Objectives (Table 7).

(g) Submit 8 copies of the progress report to the Prime Consultant for distribution to the Project Committee.

4. ASSESS THE METHODS OF EFFICIENT PARTICULATE REMOVAL WHICH WOULD UTILIZE THE PRESENT MAJOR CAPITAL WORKS OF THE PLANT. EVALUATE THE PARTICULATE REMOVAL EFFICIENCY AND SENSITIVITY OF OPERATION, ASSUMING OPTIMUM PERFORMANCE OF THE PLANT.

Elements of Work

(a) Assess the validity and implication of all information relating to particulate removal provided in Work Tasks 1 and 2 with emphasis on method, metering and sampling, etc.

(b) Using information provided in Work Tasks 1, 2 and 3 evaluate the plant's particulate removal efficiency. The basis of minimum particulate removal should be 1.0 F.t.u. It should, however, be recognized that it is desirable to strive for an operational level which is as low as is achievable.

(c) Conduct an evaluation of possible optimum performance alternatives. Include jar testing using established industry practice.

(d) Evaluate the feasibility of optimum removal using the existing plant capital works. This evaluation should consider the worst case water quality conditions, even though field testing data may not be available during the initial phase of the study (see Work Task 7).

(e) Describe the operational procedures, management strategies, and equipment required for various feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation of the alternatives.

5. ASSESS CURRENT DISINFECTION PRACTICES AND POSSIBLE IMPROVEMENT METHODS.

Elements of Work

(a) Assess the validity and implication of all information relating to disinfection provided in Work Tasks 1, 2 and 3 with emphasis on method, metering and sampling etc.

(b) Using the information provided in Work Tasks 1, 2 and 3 evaluate the plant's ability to disinfect the water. The basis of minimum disinfection should be to ensure a water quality as described in the Ontario Drinking Water Objectives.

(c) Conduct an evaluation of possible optimum disinfection procedures for the plant, with consideration also given to the reduction of chlorinated by-products in the treated water.

(d) Evaluate the feasibility of the various alternatives using the existing plant capital works.

(e) Assess the relative merits of the alternatives. Describe the operational procedures, management strategies, and equipment required for the feasible alternatives. Estimate chemical dosages, level of operational expertise, and sensitivity of operation for the alternatives.

6. DESCRIBE POSSIBLE SHORT AND LONG-TERM PROCESS MODIFICATIONS TO OBTAIN OPTIMUM DISINFECTION AND CONTAMINANT REMOVAL.

Elements of Work

(a) Prepare a list of modifications which should be considered for detailed implementation evaluation. Provide an estimated cost and possible schedule for implementation for each of the proposed modifications.

It is not the purpose of this study to provide a detailed implementation scheme for plant rehabilitation. It is, however, necessary to scope the feasible short and long-term process modifications required to achieve optimum disinfection and contaminant removals.

(b) Incorporate (a) above in the draft report.

7. PREPARE A DRAFT REPORT FOR THE PROJECT COMMITTEE'S REVIEW. (8 COPIES).

Elements of Work

(a) The report must include all information for Work Tasks 1-6.

The information must be organized and presented in a logical and co-ordinated fashion. A general table of contents (Appendix C) is provided for organizing the material in a manner consistent with other plant reports.

Submit the draft report for review by the Project Committee.

(b) Meet with the Project Committee on site at least one week after submission of the report.

(c) Prepare a separate letter report containing recommendation(s) concerning the need for additional field testing to cover quality conditions not available during the period of this study. The Project Committee may decide to delay completion of the final report until field data can be obtained to confirm the predictions of performance for the worst case water conditions.

8. PREPARE THE FINAL REPORT.

Elements of Work

(a) Conduct additional field testing if required. Discuss the implementations of the results with the Project Committee if the results differ from the predicted performance.

(b) Amend the report as per review comments, incorporating additional field data if required.

(c) Submit 25 copies of the final reports (including the colour photographs) to the MOE for distribution.

APPENDIX F

PLANT EXPANSION AND CERTIFICATES OF APPROVAL

FUND	92 WATER	
FUNCTION	4 ENVIRONMENTAL SERVICES	
CLASS OF WORK	17 WATER FILT. & PUMP.	

DEPARTMENT WORKS
PROJECT NO. 4715

REGIONAL MUNICIPALITY OF OTTAWA-CARLETON
CAPITAL BUDGET FORECAST
PROJECT INFORMATION SHEET

CODE 51-

1. PROJECT NAME & DESCRIPTION

WORKS-IN-PROGRESS Britannia Water Filtration Plant Expansion
- Phases I and II

2. COMMITMENTS MADE ___ NO X YES (PLEASE SPECIFY)

In the 5 Year Capital Forecast in 1985-89 for 1984-89, in 1986-90 for 1986-90 and in 1987-90 for 1987-90.

COMMENCEMENT DATE 1985 COMPLETION DATE 1990

3. PROJECT DETAIL & JUSTIFICATION

Water consumption demand projections have defined a need of additional water treatment capacity by 1988. The plant expansion is needed to satisfy system demands during shutdown of Lemieux Island Plant scheduled for major intake rebuilding in 1989.

Expansion schedule outline:
Phase I - Addition of two mixing/settling tanks, plus six filters
- commence late 1986 - complete early 1989
Phase II - Addition of pumping station, laboratory, administration and support facilities
- commence early 1988 - complete early 1990

The expansion will increase the production capability of the plant from 225 MLD to 360 MLD.
Chemical feed improvements is rescheduled to 1990 to allow for further field testing.

___ ORIGINAL ___ REHABILITATION ___ REPLACEMENT X ADDITION

4. COMPARATIVE INFORMATION

	1987	1988	1989	PROJECT TOTAL
1987-1991 BUDGET ($000)	9905	8206	3671	26483

5. EFFECT ON FUTURE OPERATING BUDGETS

Additional maintenance/operating costs will result.

6. REFERENCE MAP OR LIST OF PROGRAM LOCATIONS

7. APPROVAL

ORIG. DEPT.

8. CONFORMS OR DOES NOT CONFLICT WITH THE REGIONAL OFFICIAL PLAN

PLANNING DEPT.

Att. 2

Certificat d'autorisation (eau)

Number / Numéro 7-0506-86-87

1234-

Whereas / *Attendu que* .... REGIONAL MUNICIPALITY OF OTTAWA-CARLETON ....

has applied in accordance with Section 23 of the Ontario Water Resources Act for approval of:
a fait, conformement à l'article 23 de la loi sur les ressources en eau de l'Ontario, une demande d'autorisation.

Modifications to the Britannia Water Treatment Plant in the City of Ottawa t
provide a treatment capacity of 360 ML/day for a serviced population of
150,000 people consisting of the installation of one (1) additional low lift
raw water pump with a rated capacity of 1157 L/s, the installation of two (2
in-line chemical blenders, the construction of two (2) sets of hydraulic
flocculation/mixing tanks each consisting of four (4) 3-pass cells with a
total volume of 2053 m^3, the construction of two (2) settling tanks each wit
a total volume of 2570 m^3 and each equipped with inclined plate settlers eac
sized to provide a velocity of 1.09 m/hr over the horizontal projected
surface area at a flow of 135 ML/day through both settling tanks the additio
of six (6) dual media rapid sand filters each with a surface area of 135 m^2
including washwater troughs, surface wash systems and underdrain systems, th
addition of one (1) clearwell with an effective storage volume of 4.5 ML, th
installation of one (1) additional Zone 1W high lift pump with a rated
capacity of 694 L/s, one (1) additional Zone 2W high lift pump with a rated
capacity of 1041 L/s, the installation of one (1) additional filter backwash
pump rated at 1736 L/s with provisions for the installation of an additional
backwash pump and two wastewater transfer pumps, all including electrical
equipment computer control and instrumentation, additional chemical storage
facilities, relocation of existing chemical storage facilities, construction
of a workshop, laboratory and service facilities, yard piping,
interconnecting piping, valves and appurtenances, all in accordance with the
engineering plans, feasibility report dated May 1985, Master Plan report
dated May 1985, predesign report dated February 1986, plate settler pilot
test report dated October 1986 and engineering specifications, all prepared
by Gore and Storrie Limited, Consulting Engineers, at a total estimated cost,
including engineering and contingencies, of TWENTY TWO MILLION TWO HUNDRED
AND FIFTY THOUSAND DOLLARS ($22,250,000.00), subject to the following specia
terms and conditions which are considered necessary by the undersigned.

.../2

Now therefore this is to certify that after due enquiry the said proposed works have been approved under Section 23 of the Ontario Water Resources Act
Le presente document certifie qu'après vérification en bonne et due forme la construction dudit projet d'ouvrages a été approuvée aux termes de l'article 23 de la loi sur les ressources en eau de l'Ontario.

This Certificate of Approval supercedes previous Certificate of Approval No. 7-0506-86-006 issued at Toronto on the 29th day of August, 1986.

DATED AT TORONTO this 25th day of Feb/87
DATE A TORONTO ce jour d

Attn:-Ms. C. Brown, Clerk, R.M.O.C.
cc:-Mr. L.L. Larson, Dir., Engineering Services
-Mr. J. Cyr, Clerk, City of Ottawa
-Mr. R. Cuscott, MOE SE, Reg. Dir.
-Gore and Storrie Limited

/an

Director / Directeur

of the Environment / de l'Environnement

Certificat d'autorisation (eau)

Number Numero 7-0506-86-67 (CONTINUED)

Whereas Attendu que

- 2 -

of d

has applied in accordance with Section 23 of the Ontario Water Resources Act for approval of
a fait conformement a l'article 23 de la loi sur les ressources en eau de l'Ontario, une demande d'autorisation

SPECIAL TERMS AND CONDITIONS

(1) No portion of the works shall be constructed and no tenders for construction accepted on any portion of the works until final plans, specifications and engineer's report are submitted to and approved by the Director.

(2) A report must be submitted to the Regional Director, Southeastern Region, Ministry of the Environment, by October 30, 1987 outlining the effects, if any, of the untreated wastewater discharges from the Britannia Water Treatment Plant on the Ottawa River.

Now therefore this is to certify that after due enquiry the said proposed works have been approved under Section 23 of the Ontario Water Resources Act
Le presente document certifie qu'apres verification en bonne et due forme la construction dudit projet d'ouvrages a été approuvee aux termes de l'article 23 de la loi sur les ressources en eau de l'Ontario

DATED AT TORONTO this 25th day of Feb/87
DATE A TORONTO ce jour d

Director Directeur

Environment | Ministère de l'Environnement

Certificate of Approval (Air)
Certificat d'autorisation (Air)

Number / *Numéro*
8-4113-88-896

Owner Operator *Propriétaire exploitant*

The Regional Municipality of Ottawa-Carleton
495 Richmond Road
Ottawa, Ontario K2A 4B2

Located at *Situé(e)(s) à*

Britannia Water Purification Plant, 2731 Cassels Street, Ottawa, Ontario

This approval is for *La présente autorisation s'applique*

the installation of one (1) standby generator set having a power output of 1,563 kilowatts, driven by a Caterpillar Model 3606 diesel engine with a fuel consumption rate of 376 litres per hour, exhausting through a stack extending 7.2 metres above grade,

all as per application by Gore & Storrie Limited dated September 9, 1988.

DATED AT TORONTO this 13 day of March 1989
DATÉ À TORONTO ce *jour de*

Director Section 8
Environmental Protection Act
Directeur Section 8